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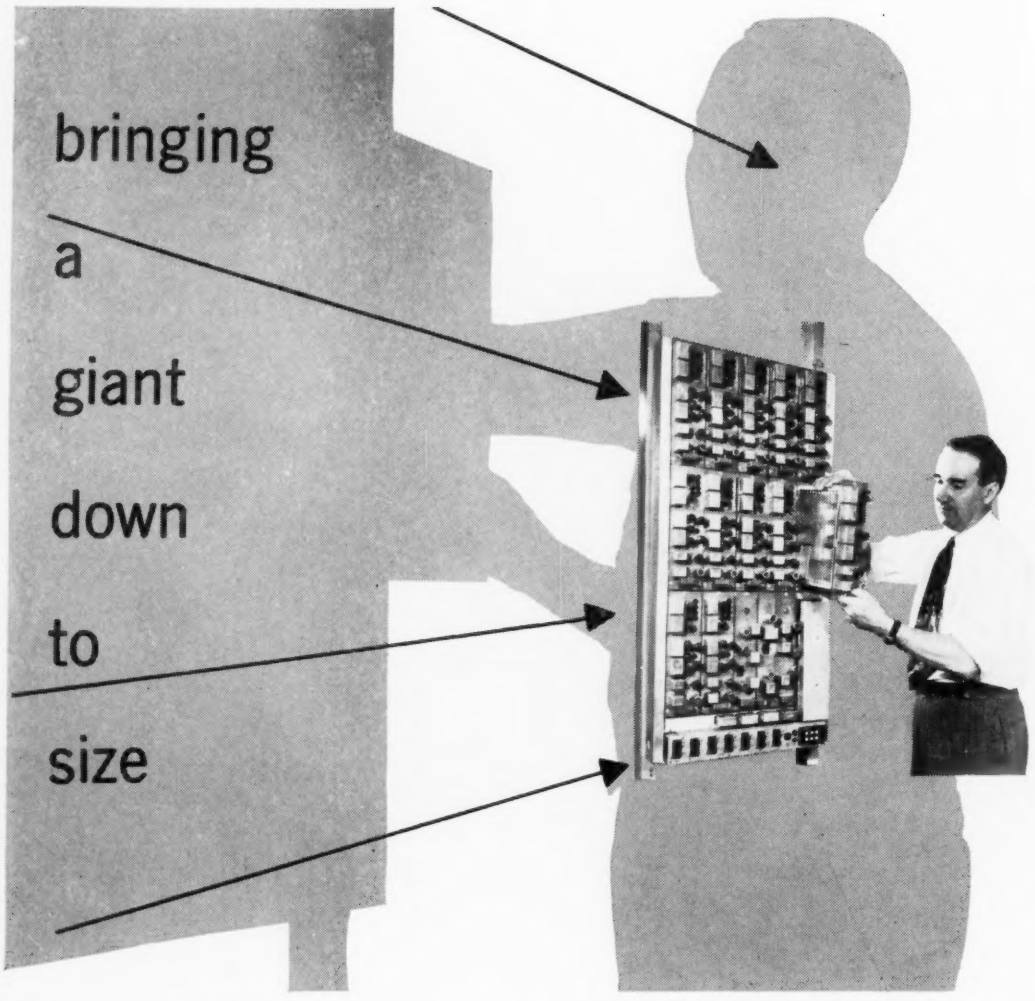

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THE SCIENTIFIC MONTHLY

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Established 1872 as *The Popular Science Monthly;* since 1915 an official publication of the American Association for the Advancement of Science.

Publication office, Business Press, Inc., 10 McGovern Ave., Lancaster, Pa. Orders for subscriptions and requests for change of address should be directed to the Circulation Department, A.A.A.S., 1515 Massachusetts Ave., N.W., Washington 5, D. C. Subscriptions: $7.50 per year; single copies 75 cents. Four weeks are required to effect change of address.

Address all correspondence concerning editorial matters and advertising to THE SCIENTIFIC MONTHLY, 1515 Massachusetts Ave., N.W., Washington 5, D. C. The editors are not responsible for loss or injury of manuscripts and photographs while in their possession or in transit; all manuscripts should be accompanied by return postage. The American Association for the Advancement of Science assumes no responsibility for the statements and opinions expressed by contributors.

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Science and Technology

(From the Month's News Releases)

Astronomy in the News

Milton L. Humason, of the Mount Wilson and Palomar observatories, reported to the Astronomical Society of the Pacific recently that in the spectra of light from faint nebulae he had found red-shifts corresponding to speeds ranging up to more than one fifth the speed of light. With the world's largest telescope he has now extended the observed range of the law by 50 per cent, indicating that the universe is expanding at an almost unbelievable rate far out into space. The National Geographic Society–Palomar Observatory Sky Survey has also announced the discovery by Albert G. Wilson and Robert G. Harrington of a small comet in the constellation of Ophiuchus.

On the other side of the continent, Harvard College Observatory is on the trail of meteors as small as buckshot with a new 5,000-pound Super-Schmidt Meteor Camera designed by Perkin-Elmer, with the assistance of the Optical Glass Division of the National Bureau of Standards. Funds were provided by the Navy Bureau of Ordnance. Harvard will receive a second camera within a few months; later two will go to the University of Ottawa and two more to the USAF Geophysical Research Directorate, Cambridge, Mass., for study of the behavior of extremely fast projectiles in regions of low air density.

Meanwhile, Westinghouse is building at its Sunnyvale, Calif., plant coronagraphs for virtually continuous daytime study of the sun's corona, through the use of "artificial" eclipses. The two new instruments will be used near Climax in the Colorado Rockies and on Sacramento Peak, near High Rolls, N. M. Basic research is expected to make possible accurate long-range terrestrial weather forecasting and to unlock some of the secrets of the atom and the ionosphere. Among the many scientists engaged in the work are Donald H. Menzel, Walter O. Roberts, and Marcus O'Day.

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Several thousand plastic pillow balloons carrying up to 200 single $6'' \times 4''$ sheets of paper with printed messages on both sides were released last month over Czechoslovakia in Operation "Winds of Freedom," experimental project of the Crusade for Freedom. *Svoboda,* Czech for freedom, is imprinted in 5-inch letters on both sides of the balloon, which tends to float at a constant altitude. It returns to earth by leakage through pores of the fabric and catches on bushes and fences. At right technician releases second type of carrier, rubber balloon filled with helium or hydrogen gas. It climbs rapidly into the upper winds that blow always from west to east. Carrying a load of 3.6 pounds of messages, or 2,200 single sheets, it bursts at 30,000 feet, scattering messages over a large area. Both plastic and rubber balloons follow predetermined paths deep into the target country.

4,000 letter-size records will hold up to 25,000 records on Kard-a-Film. Indexing can be done on both the card and on the film, and the card may be tabbed, labeled, coded, or colored. It is usable with all known filing systems.

Early Diagnosis

Although the colostrum formula for pregnancy determination was discovered several years ago, application of the so-called Q-Test has not been general. By means of a microdispenser the formula may now be injected in the superficial layer of skin in the patient's forearm. This raises a wheal about 0.5 cm in diameter. If pregnancy exists, the wheal does not increase in size, whereas on the nonpregnant woman it will double or triple in size within 30 minutes. Accuracy is said to be approximately 95 per cent.

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Optical Illusion

With the star finder you, too, can learn to identify the Great Bear, the Scorpion, Orion, and many more constellations, as well as planets. Thirty different charts of the heavens are furnished with this new optical instrument that projects them on the night sky, apparently labeling the stars. Included is a list of visible planets and a key to how to find them for the next two years.

Markers

Sleeve-type markers of rigid plastic have an overlay of clear plastic to protect lettering or color banding and are made as small as 1/16 inch in diameter or as large as 3 inches. Flat-type markers come in any size, shape, or thickness, punched with any number of holes of any shape. More expensive is the Vari-Typer branding machine that looks and operates like a typewriter. Tubing used for wire terminals is run through the machine and permanently branded with an electric heating unit. There is changeable type, as well as special symbols and foreign languages.

Pellet-Borne

The Agricultural Experiment Station at Fayatteville, Ark., has devised an interesting technique for rice field mosquito control, where the critical problem has been to insure that a lethal dose of an insecticide would fall through the rice foliage and into the water. Inexpensive bentonite pellets have been developed that will penetrate the cover and release the toxicant after coming in contact with water. Heavier than fine dusts, sprays, or aerosols, they drift less and can be applied from greater heights, making it feasible to use smaller, cheaper, and slower-powered airplanes.

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X-Ray Technology

Xeroradiography (pronounced "Zeroradiography") is a fast, low-cost, dry, direct-positive process for producing X-ray images. Battelle Memorial Institute, in cooperation with the Haloid Company and General Electric X-ray Corporation, is working on the process for application to fast, economical industrial X-ray inspection. It may also possibly be used in the inspection of ordnance and other war material and in the field of medical diagnosis. In 1949 Charles D. Oughton and Eugene C. Ricker, of Battelle, won first prize in the Color Division in the Third International Photography-in-Science Salon, sponsored by THE SCIENTIFIC MONTHLY and the Smithsonian Institution, for their transparency "Xerographic Developing Process," from which xeroradiography has been evolved.

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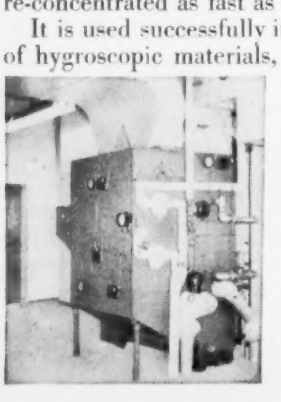

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THE
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SEPTEMBER 1951

The Palomar Observatory

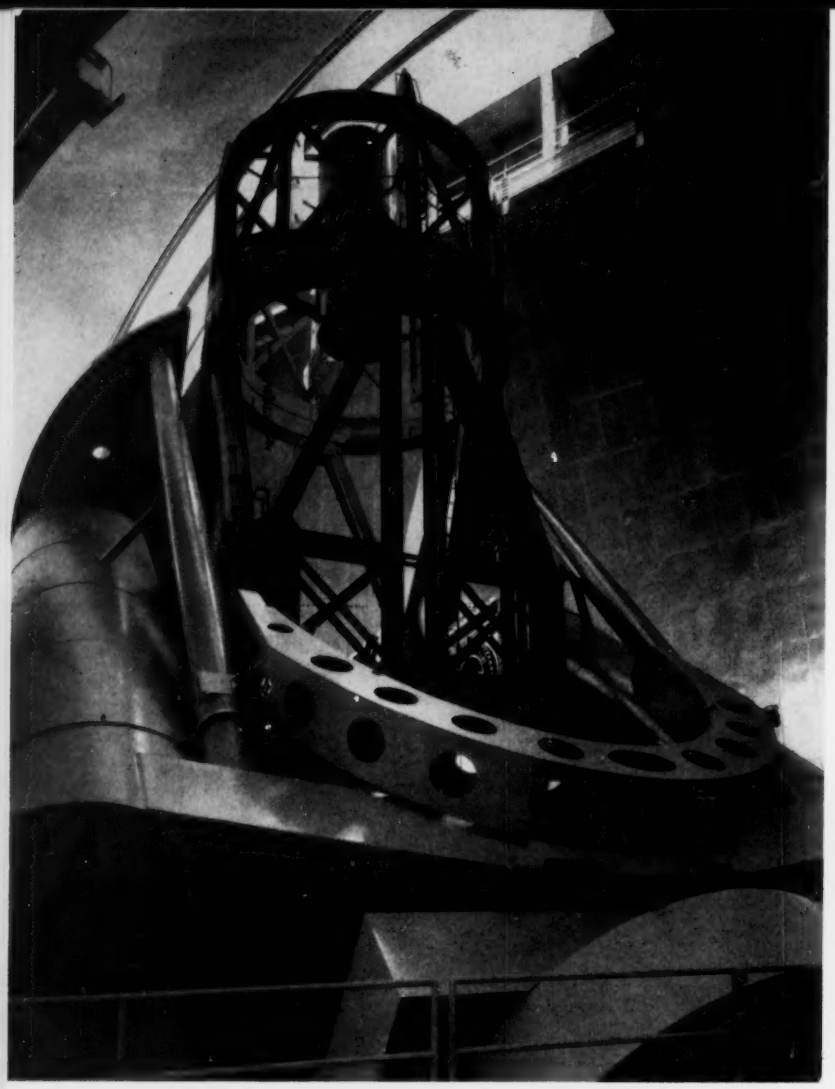
I. S. BOWEN

Dr. Bowen took his Ph.D. in physics at California Institute of Technology in 1926, immediately joining its staff as assistant professor. Since 1948 he has been the director of Mount Wilson and Palomar observatories. He has been the recipient of many honors, including the Draper medal of the National Academy and the Potts medal of the Franklin Institute. His article is based on an address before the National Academy of Sciences (of which he is a member) during its annual meeting last April in Washington, D. C.

THE great modern advance of science beyond its accomplishment in any previous civilization is undoubtedly due to the adoption of the experimental method and the development of various instruments for the observation and measurement of natural phenomena. One of the oldest of these instruments was the telescope, which made its appearance early in the renaissance of science at the beginning of the seventeenth century. At once the whole science of astronomy was revolutionized by the observations made with its aid. For the past three and a half centuries the telescope has been the chief observational tool of the astronomer. Almost from the beginning of this period two main types of telescopes have competed for the favor of astronomers. The first was the refractor. During its first period of favor in the seventeenth and early-eighteenth centuries this used a single nonachromatic lens to bring the rays of light from a distant object to a focus. With the demand of astronomers for higher and higher magnification and resolution, it became necessary to build instruments of longer and longer focal lengths to avoid the deleterious effect of the nonachromatic lenses. These resulted, late in this period, in great cumbersome instruments several hundred feet long.

Despairing of the possibility of avoiding these chromatic defects, Newton in the 1670s introduced the second type, or reflector, which depends on a concave mirror to bring the light to a focus. As techniques of casting and polishing large mirrors of speculum metal were perfected, these reflecting telescopes gradually took over most of the work of the astronomer. This first period of the reflector culminated in the 48-inch telescope of the elder Herschel late in the eighteenth century and the 72-inch of Lord Rosse early in the nineteenth century.

In the meantime, however, the refracting telescope had been given a new lease on life with the invention of the achromatic lens. At first the lack of large homogeneous disks of the special kinds of glass required limited the use of the lenses to instruments too small for serious astronomical studies, but with the advances in the glass industry during the first half of the nineteenth century this limitation was removed. At once the greater light efficiency and permanence of the refractor in comparison with the speculum mirror brought the refractor into favor again. As a result, the last half of the nine-



The Hale 200-inch telescope. Upper part of the cylinder in the center of the telescope is the observer's cage. Lower part houses the auxiliary mirrors for the Cassegrain and coudé arrangements.

teenth century was the period of construction of the great refractors in Europe, and particularly in the United States.

At this stage George E. Hale entered the field of astronomy and became the person chiefly responsible for the construction of the largest of the refractor-type instruments—the 40-inch telescope of the Yerkes Observatory, completed in 1897. Dr. Hale, it may be recalled, was very active in the affairs of the National Academy of Sciences and was largely responsible for the organization of the National Research Council in World War I. Hale, always an imaginative and forward-looking scientist, soon realized the limitations of the refractor for the future problems of astronomy. Thus, even the so-called achromatic lens was only achromatic over a short range of wavelengths, and the larger the telescope the shorter the range. The many astrophysical problems that were already attracting attention at the beginning of the present century made it increasingly important to be able to study the whole range of wavelengths from the ultraviolet to the infrared. Furthermore, at this same period photographic techniques were rapidly replacing visual observations in astronomy, and the range of achromatism of the large refractors was so short that a single instrument could not be designed to cover simultaneously the region of maximum photographic sensitivity in the blue-violet and the region of maximum visual sensitivity in the yellow-green.

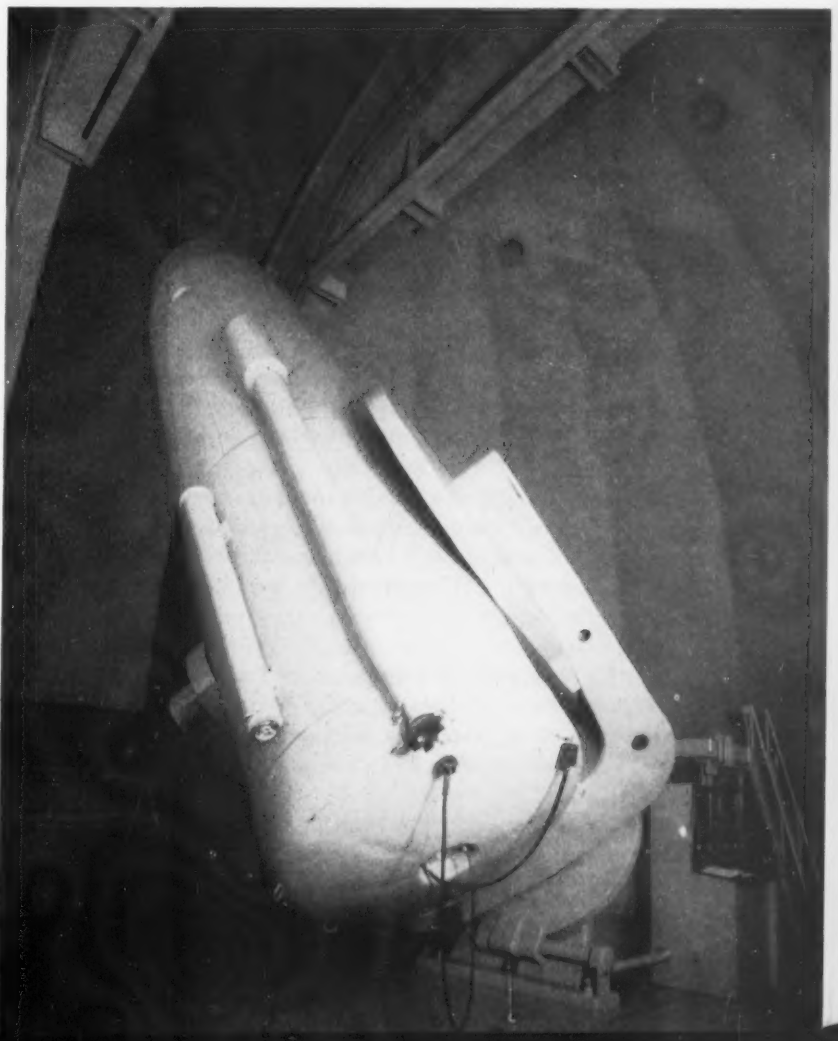
All of these factors pointed back to the reflector, with its perfect achromatism, as the instrument of the future. Fortunately the two greatest disadvantages of the earlier reflectors—the low reflecting power of the speculum metal and the necessity of refiguring the mirror at one- or two-year intervals as it became tarnished—had been eliminated by the invention of the silver-on-glass mirror. Several attempts at the construction of astronomical mirrors of this type had been made, notably by Common in England. A failure to understand the problems of mirror flexure, particularly as larger sizes were attempted, led to rather indifferent success, however.

With these circumstances in mind, Hale turned to the reflector as the next logical step in attaining greater telescope power to bring to bear on the problems of astrophysics. While he was at Yerkes a small 24-inch instrument was completed, and a glass disk for a 60-inch mirror was purchased with funds provided by Hale's father.

Another serious limitation on increase in telescopic power was the disturbing effect of the turbulence that is ever-present in the atmosphere through which the telescope must look. This was especially true at the low altitudes where most of the older refractors were located in Europe and the eastern United States. At this time a grant from the newly founded Carnegie Institution of Washington permitted, first, Hussey and, later, Hale to investigate climatic and seeing conditions on mountaintops in the semiarid Southwestern part of the United States. The preliminary tests were so promising that the Mount Wilson Observatory was established as a permanent department of the Carnegie Institution, with Hale as its director.

One of the first projects of the new observatory was to finish the grinding and polishing of the 60-inch disk and to provide the mounting and housing for it. These were completed in 1908. Thanks to Hale's own engineering training, and to the engineers he brought together to design the instrument, the flexure problems that had limited the usefulness of earlier large silver-on-glass reflectors were largely eliminated. For over forty years this instument has been a most effective tool for the attack on various astronomical problems.

The very success of the 60-inch telescope, however, whetted Hale's appetite for still-larger and more powerful tools to bring to bear on the astronomical questions of the day. Even before the 60-inch was completed, experiments had been started on the casting of larger glass disks. As soon as the success of the 60-inch was assured, the experiments were pushed and plans made for the construction of a 100-inch telescope. This telescope, somewhat delayed by World War I, finally began regular observations on Mount Wilson in 1918. Again the instrument was very successful and in the hands of Adams, Hubble, Michelson, and many others has opened up new fields of research and has given a new understanding of the structure and



The 48-inch Schmidt telescope has a 72-inch mirror (hidden by the big cover fitted over bottom of tube). Instrument cannot be "looked through," so is guided with one of two smaller telescopes mounted alongside.

dimensions of the universe, as well as providing much new information on the structure and constitution of stars.

As usual, however, the observations made with these instruments raised as many new questions as they answered old ones. In many cases it soon became evident that the answers lay beyond the power of even the 100-inch telescope. Again Hale took the lead in the effort to find means for the construction of a larger instrument. This resulted in 1928 in a grant by one of the Rockefeller boards to the California Institute of Technology for the construction of a 200-inch telescope. By this time Hale had been forced by ill health to retire from the active directorship of the Mount Wilson Observatory, but the plans and policies for the new observatory were largely laid down by him.

As was characteristic of Hale, it was decided that the 200-inch should not be merely a double-sized model of the 100-inch, but that every effort should be made to introduce new methods and to develop new techniques as well as new auxiliary equipment. Substantial sums from the construction funds were allocated for the investigation of new mirror materials, new mirror coatings, and for the development and improvement of new spectroscopic and other equipment. One of the processes developed in the course of these investigations was that of evaporating aluminum on glass, a process that has largely displaced the use of silver as a mirror surface in astronomical telescopes.

Since the original selection of Mount Wilson as the site for the 60-inch and 100-inch telescopes, the tremendous growth of near-by Los Angeles had rendered this site less ideal for astronomical work because of interference by lights and smoke. Consequently, extensive studies were made of climatic and "seeing" conditions at several dozen sites in Arizona and southern California. As a result of these studies, Palomar Mountain, a 6,000-foot, flat-topped mountain, 125 miles southeast of Los Angeles, was selected as a site for the new observatory. Although the observatory as a whole takes its name from the mountain, its chief instrument, the 200-inch telescope, has appropriately been named the Hale telescope.

Since the observatory centers around the 200-inch Hale telescope, I shall begin the description of the observatory by discussing this instrument and some of the problems that had to be solved to make it a success.

First, let us consider the optical systems. One of the minor disadvantages of the reflector is that the image formed by the main mirror is located in the center of the incoming beam. In the older, smaller telescopes it had been necessary to reflect this image to the side of the telescope with a plane mirror, an arrangement known from its inventor as the Newtonian. The 200-inch telescope is the first instrument in which the incoming beam is so large that a cage to house the photographic plate and the observer can be placed in its center without obstructing a seriously large fraction of the light. Indeed, such a cage is no larger than the mirror that would be required to reflect the light to the side of the telescope. Furthermore, the use of the prime-focus position eliminates the loss of light and possible additional aberrations arising from the reflection at the Newtonian flat. The focal ratio of the main mirror as used alone at the prime-focus position is F 3.3.

In the Hale telescope a convex mirror is also provided to reflect the light back through a hole in the main mirror to the Cassegrain focus. Since this is a telephoto system, it yields a much longer focal length, with a focal ratio of F 16. Finally, a second convex mirror, plus a flat, may be used, by which the beam of light is reflected down the polar axis to the coudé focus, with a focal ratio of F 30. This latter focus remains fixed as the telescope moves and permits the use of large fixed spectrographs or other equipment.

An idea of the scale of the present instrument may be gained from a list of a few of the dimensions and weights. Thus, the main mirror is a single block of Pyrex glass 201 inches in diameter and 25 inches thick. In spite of the fact that it has a ribbed rather than a solid structure, its weight is 14½ tons. The mirror is mounted at the lower end of the telescope tube, and 55 feet away at the other end the photographic plate is located in the observer's cage. The tube that holds the plate in its proper position with respect to the mirror weighs 140 tons. In order that stars may be studied in all parts of the sky this telescope tube must be capable of being pointed in all directions. Furthermore, it must be possible to turn the telescope with great smoothness and accuracy in following a star as it moves from east to west during a long exposure.

To accomplish this the telescope tube is mounted to turn about two axes, one of them being parallel to that of the earth and the other perpendicular to it. The upper horseshoe bearing on the polar axis is 46 feet in diameter, and the total mass which rotates about this axis and which must be driven in following a star weighs more than 500 tons. The whole instrument is housed in a dome 135 feet in diameter, with a slot on one side through which the telescope looks out at the sky. The dome which

must rotate to keep the slot in front of the telescope weighs more than 1,000 tons.

It is evident that the designers and builders were faced with all the problems of a major engineering structure. For example, there were only two boring mills in the country large enough to turn the 46-foot horseshoe bearing. Obstacles arose also from the necessity of combining these large structures with the accuracy and smoothness of motion and the freedom from distortion of a small, precise laboratory instrument. One of the great difficulties was the elimination of the effects of flexure of the telescope tube. Thus, a concave mirror of as short a focal ratio as F 3.3 has a field of view of good definition only about half an inch in diameter. One of the projects undertaken with the 200-inch construction funds was the development of lenses to be mounted in front of the photographic plate to increase the size of the field of good definition to a diameter of several inches. Such lenses were successfully designed by Dr. Ross. Unfortunately, for proper operation of the lenses their axes must maintain coincidence with the axis of the main mirror in all positions of the telescope.

As already indicated, however, the telescope tube is 55 feet long, with the mirror and its mount weighing over 30 tons at one end, and the observer's cage with the photographic plate and corrector lens at the other end. With the tube designs formerly used, the tube would bend so much in turning from the zenith to the horizon that the optic axes of the mirror and corrector lens would be thrown hopelessly out of alignment. In fact, this flexure has rendered the use of the Ross lens very difficult in the older telescopes. Although complete elimination of flexure is impossible, the present tube was so designed that as the tube is tipped from the vertical to the horizontal the mirror and the cage shift sidewise parallel to each other and by the same amount, thereby maintaining coincidence of the optic axes of the main mirror and the corrector lens. Recent optical tests have shown that this design was so successful that in no position of the telecope does the intersection of the optic axis of the main mirror with the corrector lens depart by as much as 0.01 inch from its mean position.

Another difficulty was the provision of an accurate and smooth drive for making the telescope follow the stars from east to west. In order that images shall not be enlarged during long exposures, it is necessary that the telescope turn smoothly, without departing at any time from its correct orientation by more than 0.1 second of arc. Obviously the bearings on which the 500-ton telescope and yoke turn must be smooth and frictionless. Oil pad bearings into which oil at a pressure of several hundred pounds per square inch is continuously forced are used. These are so frictionless that the 500-ton mass can be moved by one finger.

The telescope is driven through a very precise train of gears, a 1/12-hp synchronous motor supplying the power. Most of this power is used in the gears, only a few millionths of a horsepower being required by the telescope proper. The motor is driven by alternating current, whose frequency is controlled by a vibrating string, the frequency of which can be varied to correct for refraction of the atmosphere. One of our chief unforeseen difficulties has been that the friction is so low that if vibration of the telescope is started by wind or a sudden movement of the observer in the cage several minutes are required to damp it out.

The greatest problem of all was, of course, the figuring and mounting of the main 200-inch mirror. As in all precision optics, all points on the surface must be accurate to a few millionths of an inch. This accuracy is standard practice for small optics, but it is less easily maintained over an area of hundreds of square feet. Even the figuring of such a large surface would have been a fairly straightforward job with present techniques if the mirror were to remain in one orientation in a room with thermostatically controlled temperature. Unfortunately, the mirror must maintain this accuracy in all orientations and while subjected to all the changes in temperature of outside air at night.

Here, again, the very size of the mirror greatly magnified the problems. Thus, a small mirror 6 or 8 inches in diameter and an inch thick can be supported on the conventional three points necessary to define its position and retain its shape without appreciable flexure as its orientation is changed. As the size is increased, even though the thickness remains proportional to the diameter, the flexure under its own weight increases as the square of the diameter, until in the 200-inch mirror the flexure on a three-point support would be 500–1,000 times the permissible amount. Obviously supports had to be provided at many additional points. Furthermore, they could not be rigid supports, since any supporting base would also bend by too large an amount. The solution was finally found in 36 supports, each consisting of an elaborate system of levers. Each of these is so designed that it exerts in all positions of the telescope just the proper force on the section of the mirror assigned to it to counterbalance the pull of gravity.

The mirror blank was cast of Pyrex by the Corning Glass Company in 1935. After annealing and cooling slowly for nearly a year it was brought

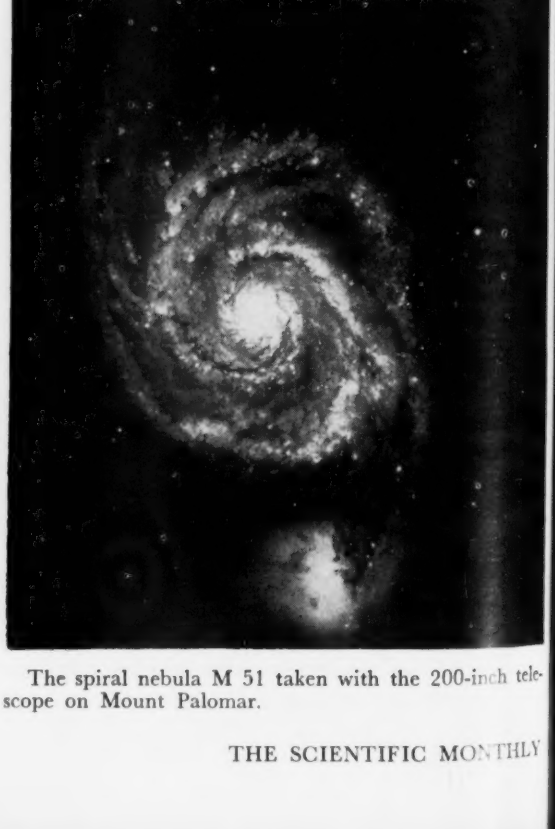
to Pasadena, and the tedious work of grinding and polishing began. After seven years of grinding and figuring, plus four years of inactivity caused by World War II, the mirror was finally ready to move to the mountain late in 1947. There it was aluminized, and the long series of tests, adjustments, and minor modifications, always expected in a project of this size, was begun. Among other things the tests showed that the original support system had friction of a little over 1 per cent, which caused the mirror to deform slightly when moved from one orientation to another. The lower part of each lever system was replaced in the summer of 1948, and tests in the fall showed that the friction had been successfully reduced to about 0.125 per cent. Study of the behavior of the mirror at the same time showed that the outer edge cooled faster than the center back when subjected to sudden thermal shock. This was largely corrected by installation of fans and thermal insulation at the proper places. Indeed, at the present time the 200-inch, in spite of its greater size, is much less disturbed by thermal changes than the older 100-inch on Mount Wilson.

Finally, all the tests, including the final tests in Pasadena, had indicated that the outer edge was too high by about 20 millionths of an inch. The tests in the laboratory were of necessity made with the axis horizontal, and it was anticipated that when the mirror was placed in the telescope with its axis vertical this outer edge, which extended some 10–20 inches beyond the outer row of supports, might deform downward. Because of this it was considered unwise to remove the edge before going to the mountain. The tests of the mirror in the telescope indicated that this deformation was not as large as feared. By the spring of 1949, however, the complete investigation of the behavior of the mirror in all orientations gave us the confidence to remove the raised edge. The mirror was removed from the telescope in May and figuring begun. The actual polishing time required for the removal of the edge was only seven hours, but about five months were required for the tests to determine the amount of error remaining after each period of polishing. On the completion of the refiguring the mirror was realuminized in October 1949, and regular scheduled operations began November 12, 1949.

Following the completion of the main telescope, various types of auxiliary equipment were built and installed. Among these were two Ross corrector lenses for increasing the field of good definition of the large mirror. In addition, several spectrographs are being provided to analyze the light of various astronomical objects.

These spectrographs range from low-dispersion instruments of extreme speed, for the analysis of the light of a nebula hundreds of millions of light years away, to long-focus, high-dispersion instruments for the detailed study of the light of a bright star. Thus, the low-dispersion spectrograph spreads the light of the object under investigation into a spectrum only 0.1 inch long, but uses a camera of extreme speed operating at a focal ratio of slightly less than F 0.5. At the other extreme is the large coudé spectrograph. As a dispersing unit this spectrograph has a composite grating made up of four large gratings, each with a ruled surface $5\frac{1}{2} \times 7$ inches mounted to handle a beam of light 12 inches in diameter. Five cameras having focal lengths ranging from 8 inches to 12 feet, and operating at focal ratios from F 0.7 to F 12, are provided to give dispersions up to 2.3 A/mm. This is nearly half the dispersion used by Rowland in his classical studies of the solar spectra, yet it is feasible with the present instrument to photograph at this dispersion the spectra of an eighth-magnitude star, i.e., two magnitudes fainter than any star visible to the naked eye. Some idea of the size of the spectrograph may be gained from the fact that one of the camera mirrors has a diameter of 4 feet, and another 3 feet.

In addition to these auxiliary instruments to work with the light collected with the 200-inch



The spiral nebula M 51 taken with the 200-inch telescope on Mount Palomar.

telescope, other smaller, wide-angle telescopes are provided at Palomar to guide and supplement the work of the Hale telescope. Thus, the field of view of a reflector of the paraboloid type such as the 60-inch, 100-inch, and 200-inch telescopes is very small—so small, in fact, that it is estimated that in their thirty to forty years of operation only 1–2 per cent of the sky has been photographed by the 60-inch and 100-inch telescopes.

Fortunately, a new optical design combining a spherical mirror with a lenslike corrector plate was brought out by Schmidt in 1931. This design gives superb definition over a very large field of many square degrees. Two telescopes of this type, of 18-inch and 48-inch aperture, are already in operation on Palomar Mountain, the latter being the largest telescope of the Schmidt type now in operation.

In a joint project with the National Geographic Society, the 48-inch Schmidt telescope is now engaged in photographing the whole sky visible from Palomar Mountain in both blue and red light. This survey should bring to light many objects for detailed study with the 200-inch, as well as provide much statistical data for the study of the distribution of various types of objects.

This is the story of the design and construction of the 200-inch telescope and its auxiliary equipment. I am happy to say that all the tests thus far made and the actual use of the instruments to date have indicated that the Hale telescope comes fully up to specifications and our hopes for it. Although much satisfaction comes from the completion of such a major instrument of research, we must continue to bear in mind that the telescope is but a tool and that the true measure of its success will be the scientific results obtained with it. I shall therefore use the remaining space for a discussion of some of the initial problems. Our first program is concerned with a study of the major structures of the universe. It was early realized that the sun is one of some billions of stars arranged in a flat disklike structure having a diameter of 100,000 light years and known as the Milky Way, or Galaxy. Outside the Milky Way are a large number of faint objects often having a spiral structure, the brightest of these being the Andromeda Nebula. One of the early successes of the 100-inch telescope was its use in the hands of Hubble to resolve the Andromeda Nebula and a few other objects of this type into stars. This permitted the identification of certain characteristic stellar types, such as the Cepheid variables, whose absolute brightnesses were known from examples in our own system. Comparing the absolute brightness with the apparent brightness in these nebulae, Hubble was able to measure the distance and therefore to determine the absolute size and absolute brightness of the nebula he could resolve. The Andromeda Nebula turned out to be an almost exact twin in size and general structure to our own Milky Way system.

Unfortunately, the range of the 100-inch telescope was so limited that only a very few of these objects could be resolved into stars, too few to provide quantitative measures of distances and sizes of a representative sample of them. The 200-inch telescope will, however, resolve several times as many of these objects, and one of the projects already in progress is both to improve the measurements on such objects as the Andromeda Nebula and to extend these determinations to a much larger number of nebulae. When this study of a larger sample of nebulae has provided a dependable picture of the distribution in size and absolute brightness of these objects, it will then be possible to compare the data with the apparent size and brightness of even the most distant of the objects, and thus to obtain a measure of their distance and true position in space. The second phase of this program, then, consists of a study of the distribution in space of these nebulae out to the extreme range of the 200-inch telescope, i.e., throughout a sphere some 2 billion light years in diameter. For these investigations of distribution, the nearer objects will be studied with aid of the complete coverage of the sky with the 48-inch, and spot checks out to the extreme range of the 200-inch will be made in fields taken with it.

This survey should provide answers to many questions of fundamental importance concerning the major structure of the universe, such as: What are the sizes, luminosities, and structural types of the extragalactic nebulae? What is their distribution in space; i.e., is this distribution uniform or nonuniform? In particular, does their number per unit of volume fall off at greater distances, or is the number constant out to the extreme edge of the observable universe?

Another group of problems depends on the analysis of light of the stars or nebulae with the spectrograph. One of these spectroscopic projects, already well under way, is a part of the general structure-of-the-universe problem, and consists of the measurement of the radial velocities of spiral nebulae at distances beyond the range of the 100-inch. Earlier work by Humason with the 100-inch had shown that all these nebulae are receding with a velocity proportional to their distance from us out to the limit of this instrument, at which point

a velocity of one seventh that of light had been reached. The behavior of this velocity versus distance function as the velocity reaches an even larger fraction of that of light is of great importance because of its bearing on the true interpretation of this apparent expansion of the universe.

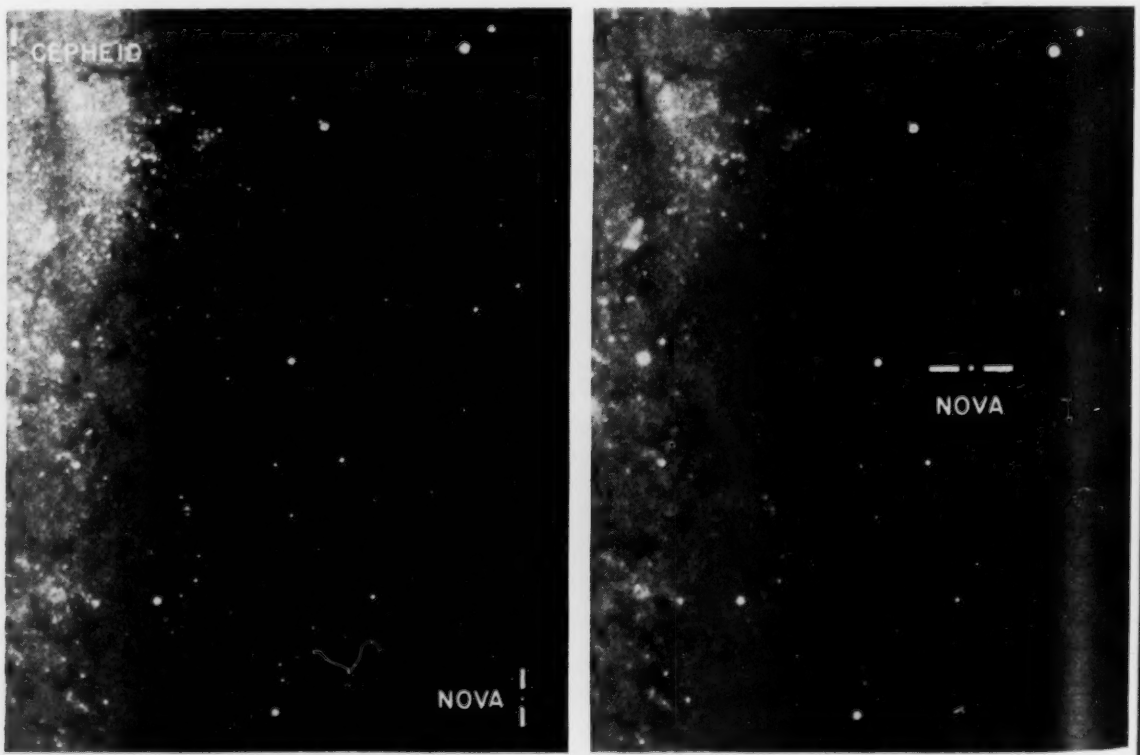
Another group of spectroscopic observations is planned to determine the rates of rotation of several of the near-by extragalactic nebulae. Other investigations will measure the random motions of individual nebulae in clusters of nebulae and the relative motion of the two nebulae in several known nebular pairs. The data thus obtained will then be used for calculations of the masses of the spiral nebulae.

A further group of problems depends on the detailed study of the high-dispersion spectrograms obtained with the coudé spectrograph. From these studies the temperature, pressures, internal motions, and magnetic fields in the atmospheres of a star or in a nebula can be obtained. These spectra may also be used to obtain a quantitative chemical analysis of the object.

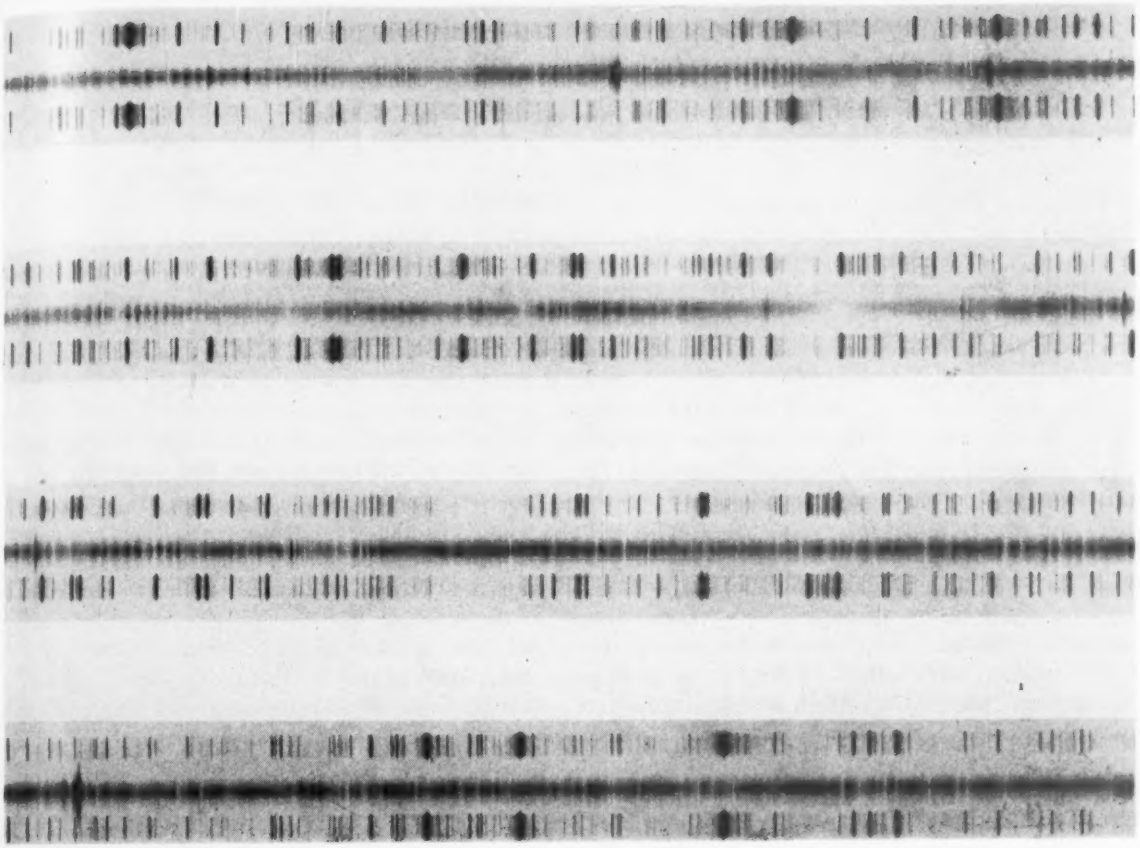
The question of the chemical composition of stars and other astronomical objects is becoming of increasing importance because of recent advances in nuclear physics. Thus, we already know that the energy radiated by the sun and most of the stars comes from the transformation of hydrogen into helium in their very hot cores. Abundance determinations therefore provide checks on the reality of various mechanisms of this type and yield information as to the amount of fuel remaining to keep these stellar fires burning.

None of these mechanisms now in operation in the stellar interiors provides a means for creating the heavier elements. It is therefore of interest to know whether all stars have the same relative abundance of these heavier atoms and, if not, to obtain information as to which elements, if any, vary together. It is hoped that when obtained such information may throw light on the origin of the heavier elements.

A substantial number of exposures, often of several nights' duration, has already been taken of the spectra of a group of planetary nebulae. These nebulae are rarefied clouds of gas surrounding in each case a very hot star from which the gases were presumably ejected. These spectra are being used for the study of the chemical composition of the gases and for an analysis of the internal motions of the gaseous envelopes. As one moves out from the star through successive layers of the gas the stage of ionization of the atoms decreases. A study of the displacement of the lines of these various ions



Greatly enlarged sections of two photographs of M 81, taken at different times, showing appearances of novae.



A portion of the high-dispersion spectrum of the long-period red variable star Mira taken with the 12-foot focus camera of the coudé spectrograph.

therefore makes possible a measurement of the velocities at all points of the object.

Another series of plates has been obtained of the spectra of the long-period red variable stars. Earlier work with the 100-inch had given satisfactory spectra while these objects were near their maximum of brightness, but the greater light-gathering power of the Hale telescope, combined with the improved spectrographs, permits following the spectra through the period of minimum brightness.

Thanks to the agreement between the Carnegie Institution and the California Institute of Technology for the joint operation of the older Mount Wilson Observatory and the new Palomar Observatory, the telescopes of both institutions are being operated as one pool of instruments available as needed to all staff members of the two observatories and to a large number of guest investigators from other institutions. The older 60-inch and 100-inch telescopes continue to be used for all programs or parts of programs that are within their range, and the 200-inch telescope is reserved for observations that this instrument alone can handle effectively. In order to maintain the maximum effectiveness of all telescopes, much of the new auxiliary equipment developed for the Hale telescope has been or is being duplicated for use with the Mount Wilson instruments.

Indeed, a modern astronomical telescope is basically a device for collecting light. The light thus collected is then recorded by a photographic plate, measured by a photometer, or analyzed by a spectrograph. As the years go by, it is anticipated that present photometers, spectrographs, and other auxiliary equipment will be replaced from time to time by more modern ones, or even by entirely new equipment of a type not yet thought of. In this way the facilities of the observatory can be kept abreast of advances in instrumental techniques and changing emphasis on problems. Thus, judging by the history of many of the older telescopes still in active use, it is to be expected that the Hale telescope will continue as an effective instrument of research for fifty to one hundred years to come. The complete story of the Palomar Observatory can only be told after the labors of many generations of astronomers have been completed.

Science and its Presuppositions

A. CORNELIUS BENJAMIN

Dr. Benjamin's articles have appeared in THE SCIENTIFIC MONTHLY *twice before ("Science and the Pursuit of Values," October [1946], and "On Defining 'Science,'" March [1949]). After receiving his Ph.D. in philosophy in 1924 at the University of Michigan, he taught the subject there and at the universities of Illinois and Chicago, taking time out for work at the Sorbonne as a Guggenheim Fellow. Since 1945 he has been John Hiram Lathrop professor of philosophy at the University of Missouri.*

IT IS commonly recognized that the most significant difference between philosophy, on the one hand, and the more specialized studies, such as science, art, religion, education, and politics, on the other, is that philosophy is concerned with the critical examination of certain concepts and beliefs that are presupposed by these more specialized studies. For example, the average scientist readily admits that, although his study is based upon certain beliefs in the uniformity of nature, the rationality of the world, and the relative attainability of truth, he is not himself, as a scientist, called upon to subject these notions to critical examination. He can argue either that such justification is not ordinarily required for the actual carrying on of science, or that *if* such justification is demanded it can readily be provided by the philosopher whose job is, by common consent, precisely the examination of the assumed notions of science. Similar considerations apply to art, religion, education, politics, and the other specialized studies. Thus there have arisen, particularly in recent years, philosophical disciplines, such as the philosophy of science, the philosophy of art, and the philosophy of education, whose assigned tasks have been the disclosure and critical examination of the unconscious beliefs and assumptions held by the scientists, the artists, and the educators.

There is reason to believe that this fundamental distinction between the task of the philosopher and that of the specialized investigator is essentially correct. But there is an unpleasant air of obscurity surrounding the entire problem. This need not be too disquieting for the latter group, since their task, as suggested above, does not include the consideration of these issues. But it is disturbing for the philosopher, both because his job *does* include the examination of unconscious assumptions, and because he is obliged in all frankness to admit that he has not, up to the present at least, succeeded either in making clear what is meant by "presuppositions" and "assumptions," or in laying bare the actual presupposed beliefs of any one of the specialized studies.

I should like to contribute what I can to solving the problem by attempting to eliminate some of the sources of obscurity. In order to keep the discussion at the concrete level, I shall confine myself to the question of the presuppositions of the sciences rather than of the arts, religion, politics, or education. Since essentially the same considerations apply wherever the question of presuppositions arises, the conclusions will not be unduly restricted by this limitation.

What Does the Scientist Believe?

When one approaches the problem empirically and asks practicing scientists what assumptions are involved in their procedures, he is likely to receive answers that are fundamentally the same, though the diversity in emphasis and in formulation may suggest greater disagreement than is really the case. The common element is usually expressed in terms of a belief in the rationality of nature, or in the adequacy of the scientific method as an instrument for exploring the world, or in the (at least relative) attainability of truth. Thus there seems to be present, at least implicitly, in the minds of most scientists a conviction that the task in which they are engaged is capable of yielding a certain measure of success, and is in some important sense worth while. Whether the goal of science is identified with theoretical understanding, or merely with an improvement in the health and well-being of mankind, is not for the moment important. What is significant is that the ideal, however formulated, is judged to be most effectively attained by the existing method, together with such improvement as may be introduced in the years to come, and is sufficiently important to warrant the sacrifices that must be made in trying to reach it.

The sources of apparent disagreement in the statements of presupposed beliefs lie in the fact that some philosophically minded scientists are not content to let the issue rest at this point. They wish to determine in some more basic way the conditions that would have to be met by the world, by the scientist, and by his method, if the scientific goal is to be attained. In this attempt certain scientists emphasize the criteria which must be satisfied by nature herself—objectivity, uniformity, simplicity, etc. A common form of this solution, which runs from Pythagoras to Sir James Jeans, is that the fundamental stuff of the world is mathematical in character. Others call attention to the scientist—his unemotionality and freedom from prejudice, and the accuracy and caution he uses in the employment of his method. Still others believe that the primary assumptions concern the method he is using—the validity of the laws of logic, and the adequacy of his criteria of clarity and confirmability. In all these cases scientists are attempting to make somewhat clearer than is ordinarily the case the basic assumption as to a kind of rapport between the scientist and nature. It would appear that the two participants in the cognitive enterprise have entered into an unconscious agreement that each will endeavor to do his part toward the ultimate attainment of knowledge.

Just what role, then, do these beliefs about nature, the scientist, and his method play in science? The common answer is that they are "presupposed." But what is meant by this term? The suggestion of some sort of *priority* seems to be involved, and one is immediately led to ask whether it is *temporal* priority or *logical* priority.

The absurdity of supposing that the beliefs are *temporally* prior to science becomes apparent at once. To grant this would imply that the scientist, before really beginning his scientific activity, sits down and makes a thorough study not only of the scientific method itself but also of the kind of man he must be to carry on science and the kind of a world we must inhabit if it is to be knowable by scientific techniques. This is contradicted by the obvious fact that the average scientist simply does not do this. To be sure, he must have, prior to science, a kind of rudimentary knowledge of what the method is and how to use it. But no serious person would claim that he must refrain from using it, or from committing himself to the scientific enterprise, until he has assured himself of the truth of all that this involves in the way of beliefs about nature, himself, and his method. The more or less obvious fact is that most scientists begin by just "doing science." They may, in certain unusual cases, train under a good teacher who occasionally calls their attention to certain principles of method which they are using; they may, in still rarer cases, take courses in logic and scientific method as part of their scientific education. But information of this kind, although contributing to greater clarity in the grasp of the scientific method, is employed mainly to develop skills, and does not make any serious claim to justify the scientific method, or show why it "works," or to indicate what elements of "rationality" nature must contain if the method is to produce results. These fundamental problems are raised, if at all, only much later, and their solution is deemed to be of no significance to the scientific enterprise itself.

One seems led to the conclusion, therefore, that such beliefs, if temporally prior to science, must be unconsciously or only implicitly present; the scientist has such beliefs, but he doesn't know that he has them; the beliefs are "there," but the scientist cannot find them, both because they are so nebulous and because he finds it impossible to say what he means by "there." The result, in any case, is completely unsatisfactory; if the beliefs cannot be found, and if there is no empirical evidence for their existence, we might just as well deny them completely and eliminate the problem at one stroke.

There is, however, an alternative. Perhaps the beliefs are not temporally prior to science, but logically prior. According to this interpretation, the beliefs need not actually occur in advance of science, but they are the *necessary condition* for science; i.e., if they were false science could not go on. But this runs up against the stubborn fact that many scientists—good as well as bad—never think about these issues at all, even posterior to science. Yet the ability of such individuals to practice science and to produce results seems to be in no serious way affected. Even if one were to force the issue by asking these scientists whether they do not feel the need for such beliefs, or how they would attempt to justify them *if* the need for them could be demonstrated, he might well receive a very disappointing reply. He might be told that the entire problem is purely academic, since the healthy fact seems to be that science "works," and all such beliefs are pale and anemic by comparison. Perhaps some scientists would be willing to concede that the beliefs, if shown to be necessary, could be accepted on "faith," or could be shown to be purely arbitrary postulates, or might even be shown to be "intuitively" true. But in any case commitment to them would involve no serious violation of one's intellectual honesty, since the

evidence for or against them would be too vague and uncertain to be decisive.

This reaction of scientists to the problem suggests that the issue has not yet been made sufficiently clear. Undoubtedly there *is* some sense in which the scientist does take for granted certain facts about nature, himself, and his method. One has only to formulate the problem negatively to see that this is the case. Suppose, for example, a scientist were convinced not only that nature changed in some fundamental way overnight, but that the *way* in which this change took place could never be detected. The result would be that his knowledge would not carry over from one day to the next, and he would have to start anew each morning. Or suppose a scientist were convinced that man could never think rationally—that prejudice, emotionality, wishful thinking, and the like prevailed in his reasoning processes to such an extent that he could place no reliance whatever on his results. Such an assumption would have to involve something more than the generally recognized fact that these factors *do* play a role, somewhat larger than we are always willing to admit, in our thinking processes; it would have to commit us to the belief that in spite of the recognition of these pitfalls, in spite of training in objective thinking, and in spite of clear-cut knowledge of the principles of the scientific method and the most extreme caution in their use, our unconscious desires and motives, hidden prejudices, and unavoidable preconceptions would make forever impossible a rational view of nature. Or suppose, finally—to exaggerate a difficulty that has recently been disclosed by quantum mechanics—the scientist believed that whenever he observed anything the very process of observing changed the object in unknowable ways. He could then have only a post-mortem knowledge of nature, i.e., a knowledge of nature as it manifests itself to the observer, but not as it is "in itself." Science, in the usual sense, would then be impossible.

One might reply that these are all hypothetical cases, and no scientist really believes any such absurdities. But this in no way invalidates the results. On the contrary, the fact that no scientist has accepted any such beliefs—which would be extremely difficult to establish on empirical grounds—may itself be of the greatest significance. Perhaps scientists have recognized the inconsistency that would be involved in the continued pursuit of science *if* they held such beliefs; perhaps they have been too devoted to their task, and have had too strong a faith in their methods, to yield any place to beliefs that would make their enterprise absurd. Perhaps the absence of such beliefs is itself evidence of the fact that we all indulge in wishful thinking. But the point remains. Certain beliefs do seem to be incompatible with the pursuit of science. Hence, even if we cannot conclude that there are beliefs that are logically presupposed by science, we can infer that there are certain other beliefs of a negative character which, if held by scientists, would tend to discourage the continuation of their task and might even induce them to give it up entirely.

When we ask, therefore, whether there are any beliefs that are necessarily presupposed by science, the answer seems to be that such beliefs are not properly required for the *carrying on* of science, but that they are needed for its *justification*. This basic distinction between acting and justifying one's actions runs through the entire gamut of human behavior. One may act morally without at the moment being able to state the principle directing his actions, or one may enjoy a painting without at the time being able to formulate the aesthetic criterion at the basis of his appreciation. Similarly, one may pursue truth without being able either to define truth or to state what conditions must be satisfied by nature and by man if truth is to be attained. Reference to conscious standards is dispensable at times both because man has developed habits that are adequate in many complicated situations, and because he seems to be endowed with certain intuitive capacities that enable him frequently to make correct judgments without knowing how he has done so. In terms of our problem this means that science may, for relatively long periods of time, and through unexpected vicissitudes, go on its merry way without requiring any examination of presuppositions or assumptions; furthermore, science seems, in general, to be none the worse for this fact. In this sense there are no beliefs that are presupposed by science, and the insistence on the part of certain philosophers that the scientist must uncover and make peace with his presuppositions seems somewhat misplaced. He can justifiably reply that science has been doing very well, thank you, without this kind of inquiry, and the prospects seems not too bad for the future.

The Broader Need for Justification

But there are two reasons why this restricted view of science—or, for that matter, of art, religion, morality, education, or any of the other special studies—cannot be satisfactory in the long run. In the first place, situations are almost certain to arise, sooner or later, when habits and hunches no longer prove adequate. Critical reflection then becomes obligatory. Frequently these are cases in

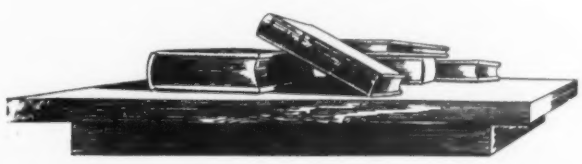
which science suffers a "shock." Examples abound in the history of science, particularly in the past century. One need mention only the discovery of non-Euclidean geometry, the negative outcome of the Michelson-Morley experiment, and the discovery of the principle of complementarity in quantum mechanics. These were all cases in which science, for the moment at least, trembled at its very foundations, and re-examination of basic concepts and presuppositions became imperative. Other situations which force the examination of assumptions occur when the scientist suffers repeated defeat, and avoids utter despair and disillusionment only by a reconsideration both of the ideals he has set for himself and of the faith he has placed in them. It is characteristic of most of the goals of life that they are accepted uncritically so long as they prove adequate, and are called up for examination only when they fail to do the job expected of them.

In the second place, one must recognize that there are individuals, scientists and philosophers alike, who seem to be provided with an unusual allotment of intellectual curiosity and will simply not remain content so long as this borderline area of assumed notions and unexamined concepts remains unexplored. They are the intellectual gadflies of science who destroy our complacency by continually asking "Why?" For them science as a going affair is essentially an invitation to indulge in this kind of speculation. They will not be satisfied with the simple statement that science "works;" for this, they point out, involves a general pragmatic principle that whatever works is to that extent justified, and why should we accept *this* principle? They will not remain content with the claim that the scientific method represents the most effective use of our reasoning powers yet developed and thus is the most adequate method for obtaining truth; for this simply invites the double-barreled inquiry: Why should we be reasonable, and is truth worth its salt?

The point is not that these questions must be answered if science is to receive ultimate justification; probably many of them cannot be answered at all. Bertrand Russell has shown that the principle of the uniformity of nature, which is at the basis of all induction, cannot itself be proved inductively; but, since it cannot be proved deductively, it cannot be known in any way to apply to nature. Probably also the objectivity of nature cannot be proved in any final manner, since all proof is essentially subjective. The questions are asked not in order that answers may be forthcoming, but in the hope that the issues which led to the asking of them may be clarified. The precise formulation of a question, even when the answer cannot be given, often contributes to better understanding.

The general conclusion, therefore, seems to be that when the scientist acknowledges having certain presupposed beliefs concerning nature, himself, and his method he does not mean that he has any conscious or clear-cut notions to which he has definitely committed himself, nor does he mean that the beliefs are required in any important sense for the continuation of science. What he does mean is that if these beliefs could be shown to be false, science would lose its justification. Hence whether or not a scientist has such beliefs, and the degree to which they are conscious and well defined, depend upon the need he feels for some grounding of his enterprise other than that involved in its continued working. If he is disturbed by some of the shocks science has suffered in the past by virtue of inadequate attention to its method; if he is more impressed with his failures than with his successes and thus finds himself concerned about the limitations of the scientific method as an instrument for exploring the world; or if he is one of those intellectually curious individuals who continually search for deeper and deeper foundations—in any one of these cases he will consider the examination of presuppositions to be an important part of his task as a scientist.

Probably it would be inaccurate to say that the scientist who pays no attention to these matters is the gadgeteer and pebble-picker who is so often held up for ridicule. On the other hand, it would be fair, I think, to say that to the degree to which a scientist shows concern for the presuppositions of his subject and for its interrelations with other areas of experience, he exhibits that broader understanding which transforms science as specialized knowledge into science as an important enterprise of the human spirit.



The Prehistoric Roots of Biology

L. P. COONEN

Dr. Coonen began teaching biology soon after he took his Ph.D. in botany at the University of Wisconsin in 1938, and has been head of the Biology Department at the University of Detroit since 1943. His present article is based on a chapter in a book he is preparing on the history of biology.

THE history of biology is the history of man. The two chronicles have common problems. Just as man's first activities are obscured in the nebulous testimony of prehistory, so is the story of primitive biology. Its interrupted chronicle, gleaned from the garbage of man's first camp sites, is scattered in time and space. The plants he chose and the animals he outwitted to fill his larder; the diseases he suffered and treated; the living objects that inspired his art—all these things have left evidence of his interests and achievements. We see that his progress was slow and hard-earned.

The current paths of biological science are equally perplexing. They divide and subdivide; they meander through the swamps of data; they detour about the unknown; they anastomose where community of objectives and conclusions are defined; they wander into and out of the other sciences, sometimes becoming temporarily or even completely lost in the maze of trails leading into the tall timber of chemistry and physics and the dense underbrush of mathematics.

We see four stages of development of the life sciences. We see that they were forged from the crude materials of primitive man's *necessity,* ancient man's *philosophy,* medieval man's *awakening observation,* and modern man's *integration* with other sciences. Further, it becomes evident that the development was cumulative; the principles in the first were retained in the second, and so on.

Prehistoric man was confronted by the same basic problems as is modern man. He needed groceries, fuel, clothing, and at times shelter and medical care. Necessity made everyone a biologist. By the same token, man may have been a physicist, a chemist, and an astronomer. But the sun, the stars, gravity, oxidation, and weather were recurring mysteries, nuisances, or pleasures, usually to be reflected upon at leisure. In contrast, a gnawing hunger could not wait; a broken leg demanded immediate consideration; reflection postponed to a rainy day would hardly suffice to meet the impending attack of a cave bear. Effective methods of recognizing and gathering edible seeds during a brief time in autumn meant life or death during the coming winter. Biological problems were vital ones. Prehistoric men probably, and primitive men certainly, had to work out their solutions individually or lose the battle for existence. Their logic may not have been patently syllogistic, but the bulk of their conclusions was sound.

Their "life sciences" were a far cry from what we understand them to be. Yet, there were the roots: Observation, comparison of data, experimentation (trial and error), and valid conclusions, all catalyzed by immediate necessity. Errors of one family or one tribe were seldom of benefit to another group, for lack of language and writing interrupted the flow of experience. Experimentation was costly; waste of effort and life was tremendous. Such was prehistoric biology.

Well-documented history of human deeds starts about 1000 B. C. Herodotus, "The Father of History," recited his chronicle in Athens in 438 B. C. But man lived long before the first historian. Prehistoric footprints, often bloody and halting, may well go back a few hundred thousand years. Cleland[1] believes that *Pithecanthropus erectus,* probably human, may have lived a million years ago. Even the American Indian's culture reaches back at least 25,000 years. Spearheads have been found among the bones of the American camel, horse, and mammoth, once-wild fauna of this continent.[2] Osborn[3] places Neanderthal man, a skilled hunter, on the European scene about 50,000 years ago. He believes that *Homo sapiens* entered Europe 25,000–30,000 years ago. His prehistory may represent 100, 200, or even 300 times the span of the historical era. This vast investment in experience would itself merit a study of early man's interests and achievements in biology.

Prehistory is concerned with things and deeds; not with the nameless individual men who did them. Their deeds were many; the evidence is heroic *in toto,* but badly scattered. Their ingenuity is described in their artifacts; their successes and prosperity are recorded, like modern man's, in their junk piles and garbage heaps; their personal

failures are often tragically immortalized by broken brain boxes, some of them ironically turned to stone, the very substance their brains turned to tools.

In this sketch of the rise of prehistoric biology there will be little attempt to maintain a running sequence, nor will a timetable be adhered to religiously. Such terms as Paleolithic (Old Stone Age), and Neolithic (New Stone Age) are relative. Progress in culture did not advance at the same rate in one region as it did in another, nor on one continent as it did on another. Despite this apparent resignation to generalities, we shall employ the fairly well-defined set of sequential terms which have evolved in the literature of anthropology and paleontology. These terms have much more reference value than the guesses in terms of centuries or millennia.

The following scheme incorporates those terms in a grill of reference. It fits Europe, where most of the work has been done. The various categories are based upon degrees of stoneworking skill of primitive peoples. The names (except those containing *-lithic*) are usually derived from the French towns near which the respective discoveries were made.

The Pleistocene, or ice age, is usually described by geologists as occupying upward of 150,000 years. During this long, poorly comprehended lapse of time four great periods of glaciation occurred in northern Europe and other boreal lands. As the glaciers slid down from the north, they gouged out lakes, piled up gravel, and transported rocks and humus sometimes hundreds of miles southward. When they finally stalled and melted, the liberated water cut new rivers and streams. The shrinking ice masses thus gently set down their burdens of rock and soil. Each glacial cycle required a minimum of 25,000 years.

Superimposed upon this pattern of geological change are the activities of certain prehistoric men. The activities are extensively recorded, but the archives are usually in poor order. Nature's records had been compiled in rock formations, and man's artifacts had been sealed among them in the sequence of their appearance and use; but impetuous nature at times obliterated the evidence, or moved the remains, or disturbed them by local cataclysms. It is thus ideal, but rarely possible, to find a series of deposits undisturbed, layer upon layer, as they were placed there by several cultures of early man.

No doubt the most complete record written in household debris is contained in the twenty-five successive layers of human rubbish found by Obermaier[4] in Castillo Grotto, Spain. Uninhibited housekeepers for a period of 50,000 years[3] left 45 feet of dust, dirt, and castoff tools and bones on the cave floor. Out of justice to the housewives of prehistory, we must state that a certain minor proportion of this was simply clay carried in by water or wind during the intervals when men did not occupy the shelter.

A brief discussion on each of the phases of culture during the Stone Age will help make the countless centuries of man's prehistory a continuous account.

Eolithic. This period is characterized, not by any human remains but by the crude stones, eoliths ("dawn" + "stone"), that were first employed by primitive man. It is significant that he did not fashion them, but rather he seems to have chosen them because they "felt right" in his hand and because they aided him in scraping hides, cracking nuts, killing animals, splitting bones, and other tasks when the bare hand would not suffice.

Prechellean. This phase is identified by the crude *coup-de-poing,* or hand stone. There was no standard form or size adopted during this period, but some crude fragmenting or shaping made the tool more adaptable and efficient than the eolith.

Chellean. The village of Chelles, on the Seine not far from Paris, suggested the name for this period in the Paleolithic. Other sites of identical culture were subsequently found in Spain, England, and other parts of France. Near St. Acheul more than 20,000 stone specimens of this culture were eventually uncovered. The particular achievement of this time—at least, the one preserved for interested posterity—was the improved hand stone. It was gracefully refined into a standardized almond-shaped tool, flaked by patient, competent hands.

Acheulean. Although this culture is represented by findings in Great Britain, Italy, Germany, Spain, Russia, Poland, Africa, Syria, India, Indo-China, Japan, and Ceylon, it receives its name from St. Acheul, the site of its first recognition. The hand stone was further refined; knives, scrapers, and other new tools appeared. Large beasts were plentiful.

Mousterian (Middle Paleolithic Period). In southwestern France, on the banks of the Vézère, is Le Moustier, the cave where first evidence of this culture was uncovered. More than twenty other regions of Europe and Asia Minor have since disclosed artifacts of the same period. For about 30,000 years man struggled for heat and food in an environment that was generally cold and damp. Mousterian men were industrious: they invented lance heads, scrapers, and awls and probably made

rather clever wood weapons and tools which, of course, turned to dust long before the first archaeologist arose from it.

More energy was required for hard work and for maintaining body temperature. Hence more food had to be collected from fen and forest; wood had to be gathered for fuel; clothing had become a necessity. This was a hard life, but these ancient men rose to meet the demands, not merely existing upon a minimum diet, but seemingly insisting upon the biggest and most ferocious of beasts for food. The mammoth and the rhinoceros, tons of bone and flesh in either case, had to be slain, and somehow they were, with crude weapons. The mammoth was much larger than our present-day circus elephant, and the rhinoceros, an almost irresistible mountain of protoplasm, was armed and armored to combat all enemies.

Because Mousterian woman, in her semidark cave, merely tossed the remnants of a barbecued shank into a corner, and her husband casually let the flint chips fly where they would, the cave floor became a rich record of their way of life.

Aurignacean (*"Reindeer Period"*). Exit Neanderthal man; enter the more-than-six-footer, Cro-Magnon. Anthropologists place the newcomer in the same genus and species as modern man. This big fellow left evidence of his presence in France, Spain, Wales, Austria, and Italy. His great size did not prevent him from becoming an aesthete: art began, personal adornment received a great deal of attention. Bone was widely used for trinkets and accessories; flint was shaped into drills, knives, weapon points, and, most important, many of these were retouched to effect a more uniformly sharp and less serrated edge. Cro-Magnon man hunted the horse, bison, and reindeer. When necessary he attacked the cave bear and the cave lion.

Solutrean. The excellent flint workers of this period left their artifacts in England, France, Poland, Bohemia, Hungary, and Germany. Solutré, in France, was first to yield its evidence; hence the name. Although the glaciers were disappearing from Scandinavia, central Europe was still cool. Human families spent some of their time in open camps; the cave was no longer a necessity. Bone and ivory needles were invented, but art seems to have degenerated with the home; some carvings were remarkable, but in general paintings were crude representations.

The Solutrean craftsman employed what is now respectfully acknowledged as the "Solutrean retouch" to his flint workings. The result was the execution of flints, worked on both sides, to resemble the perfect symmetry of a laurel or a willow leaf. Some of them are said to be so thin and delicate that they are quite translucent.

Magdalenian. Cro-Magnon men, dominant during this period, had lost their ability or interest in stoneworking, and their stone tools were inferior. Their bone tools, however, were excellent, and their carvings and engravings on bone, ivory, and horn reached a high degree of artistic perfection. The climax of this development was reached in the polychrome paintings on the walls and ceilings of the caves at Altamira, Spain. The nameless prehistoric painters were not mere daubers; they were skilled artists, all the more remarkable because they worked by the uncertain light of burning fat. More than thirty animals are represented in this artistry, with the bison and the mammoth as favorite models, no doubt because they were favorite food animals.

Azilian. As the last, or fourth, glacier was receding from the northern wastelands of Europe this culture came into being. England, Scotland, Spain, Austria, Germany, and France bear testimony of it. Both art and toolmaking had deteriorated. There were still no domestic animals and plants. Shifting tribes and clans were living from hand to mouth in the open valleys and forests. The climate was still cool but was approaching present-day temperatures, which of course vary with the seasons.

Transition, Paleolithic to Neolithic. Most probably there were no peoples in North or South America during the entire Paleolithic period just described. The evidence presented to place Old Stone Age man in the Americas is not very convincing.[1] A new culture, the Neolithic, may have arisen in Asia, diffused eastward and westward, slowly but steadily spreading over most of Europe and across the Aleutian land bridge to North America and continuing into Central and South America.

In Europe this new, enterprising people either killed off or absorbed the Paleolithic cultures. Azilian families disappeared; Neolithic man throve. The economy was changing. Hunting was no longer profitable. Paleolithic fauna became relatively scarce. Family units could no longer be maintained during the entire cycle of seasons, and a carry-over of food energy became imperative. Seed gathering began, and the young of the wild sheep and the goat were probably caught and raised in captivity. At any rate, animals were herded and confined; domestication was under way. And thus agriculture was born.

Neolithic (*New Stone Age, or "Polished Stone Age"*). Neolithic peoples were progressive: man's

lot improved by leaps and bounds. Families banded together into communities, perhaps the better to defend themselves. Very early they planted and harvested crops, and probably worked the soil a little with wooden implements. They practiced spinning and weaving and, perhaps more important, they made and used pottery. Flaking of stones for toolmaking was no longer considered the last step in this craft; the new method included grinding the surfaces smooth.

The new pot became the hallmark of gracious living, and cooked food was the standard diet. Meat was available at all times. Pigs, cows, and horses were herded or confined for convenient and continuous meat production. The dog was taken into the household as a friend and slave, often ending the unilateral pact as a stew in the wonderful new pot.

Two convenient subcultures are usually recognized in the Neolithic: the kitchen midden peoples and the lake dwellers. The former are particularly associated with Denmark, and the latter are most often identified with Switzerland. The kitchen midden peoples built mounds, or middens, by dumping kitchen refuse in community heaps year after year. A few middens reached heroic proportions, containing over a million cubic feet of bones, shells, and a scattering of broken tools. Usually mollusk shells predominated.

The lake dwellers in several European countries, but notably in Switzerland, built their houses above water on posts driven into the lake bottom. Prolonged droughts in the nineteenth century temporarily brought the lake water level down to where the wooden piles, implements, and even scraps of food and clothing were found. Several domesticated animals were in evidence. Fragments of wool and linen cloth and ropes, fish nets, and fish lines have been discovered. Seeds of cereal grains have been found and identified and, strangely enough, unleavened bread has been recognized.

Use of Land Animals for Food

Men of prehistoric periods killed animals for food. The inference is logical and irrefutable. Not only are tools and human bones of extinct cultures found with the remains of extinct animals, but cave floors are built upon skeletal fragments of animals that lived in the open country.

Very primitive Heidelberg man has left his telltale jaw among the bones of the elephant, deer, elk, and bison,[2] at least suggesting an economic interest in these beasts. Further, the rubbish of Piltdown man—always considered among the most primitive—contained a rhinoceros tooth, a hippopotamus tooth, and the leg bone of a deer, again indicating that the animals (all herbivorous) ate the man, or the other way around. Such arguments tend to be weakened by the lapse of time and the laws of chance, but the paleontologist, a tireless detective, has gathered unimpeachable evidence to prove that the hand of early man slew the beasts of his time. In Ireland a stone hammer was discovered wedged into the skull of a deer; in England, a celt forced into the skull of a bear; in Sweden, an arrowhead piercing a bear's vertebra; in Denmark, flint weapons penetrating jaw bones of beasts; and in France, an arrowhead protruding from a horse's vertebra.[5]

It seems that certain families or tribes became specialists in hunting particular animals. Perhaps a special knowledge of the animals' anatomy or habits led to special vulnerability and kept certain animals on the bill of fare year after year. Knowledge of animals was advantageous; primitive biology was paying dividends.

Meat was year-round food. In the summer, nuts, berries, and succulent plants were available. Even snails and slugs were delectable, but in the long, cold winters primitive man was becoming more and more dependent upon the concentrated energy of a meat diet. At times he could not afford to be profligate; meat, as always, was expensive. He cracked skulls to pick the brains and split long bones to suck the marrow. Split bones and broken skulls by the thousands patiently repeat that story.

Hunger was not the only whip, though it was the most important, that drove Paleolithic man to risk his life and expend his energy to bring home bear brains and bison steaks; he had an interest in the skins for rugs and clothing, and in the fat for fuel to light his hole-in-the-wall abode. But he evidently slipped into a dietary rut by his specialization.

In a cave at Echenoz-la-Moline, on the upper Saône, he left more than 800 skeletons of the cave bear,[3] a nasty dietary item to shop for. In Gourdan Cave the remains of 3,000 reindeer were accumulated.[5] Not only are these cached bones indicative of a one-track gustatory interest, but they demand a negative tribute to man's olfactory tolerance. Forty-five hundred bear bones were found in a cave near Odessa, and 2,500 ursine remains were found in Külock Cave.

Horsemeat in tremendous quantities was consumed by Aurignacean man. The wild horse was hunted, as it still can be in the high plateaus of central Asia. At Solutré horse bones are said to

cover the mountainside and reach down to the floor of the valley. Modern inhabitants call the region the "horse walls." De Nadaillac[5] says 40,000 horses were killed and eaten here. Osborn[3] places the estimate at more than 100,000 animals. Who can question the Aurignacean's practical knowledge of horse anatomy? And who would dispute his knowledge of the habits and tricks of this fleet-footed pony, since it was felled by the thousands with crude stone weapons?

The prehistoric hunter must have known the essential details of hibernation and migration. At Drachenhöhle, Styria, in Austria, he clubbed the hibernating bear, hungry and ferocious, as it emerged from its winter retreat. At Prědmost, Moravia, 1,000 mammoth remains bear mute testimony to the ancient hunter's knowledge of migration. He knew where and how to surprise the lumbering beasts as they moved in their semiannual treks to and from the Danube plains. Not all Stone Age hunters were narrow specialists, however. The Neanderthal sites at Sirgenstein emphasize the scope and variety of his hunting. There were found skeletal remains of the cave lion, cave bear, cave leopard, bear, lynx, wolf, bison, wild cattle, steppe horse, and giant reindeer, besides the goliaths of the zoological world, the woolly mammoth and woolly rhinoceros.

Modern big-game hunters, with less ferocious beasts to stalk, are considered steel-nerved, adventurous heroes. Well they might be despite their portable armory of steel-piercing rifles, telescopic sights, motor trucks, and a full complement of accessories, but primitive peoples, armed with stone-headed weapons, were evidently fortified by an uncanny understanding of ecology and natural history. They were practical biologists.

A red-ochre painting of a mammoth on a cave wall of Pindal probably served as the first biological chart for visual education. Cro-Magnon or Neanderthal man in Aurignacean times figured the mammoth, then superimposed upon it what seems to be a heart, reasonably well located (Fig. 1). Was this a "briefing board" where young hunters could be taught one important region in anatomy, the location of the most vulnerable organ? That is a tantalizing possibility.

Meat-eating before the dawn of history was probably a lusty ritual. The rugged Stone Age man and his family often scorned the small, timid species of vertebrates, perhaps for fear of losing their own vigor and virility. The swan, goose, duck, and other birds are notably absent from the Moustier cave. Early Neolithic peoples at Wangen and Mooseedorf in Switzerland disdained the hare.[6] Only one bone was found among the otherwise rich deposits of vertebrate skeletons. Lyell is not surprised; he says the modern Laplanders, although in constant contact with this rodent, maintain a hareless diet.

Certain subcultures, especially during Neolithic times, accepted the feathered animals as delectable fare. Kitchen middens of Denmark contain bones of ducks, geese, partridges, swans, and gulls.[1]

Aquatic Vertebrates and Invertebrates as Food

Not all primitive peoples fished; even some of those who lived near the sea did not. Others, however, were excellent marine and fresh-water anglers.

Prehistoric fishes, like modern ones, had to be tricked into a net or impaled upon a sharp object. Magdalenian man of 18,000 years ago used a bone harpoon[3] and somewhat later hardwood slivers, bone hooks, and stout hooks fashioned from a boar's tusk or from the shells of the mollusk *Mytilus* caught the fancy and the fish of Stone Age anglers. The net of very late Neolithic times resulted from a concatenation of ingenious ideas: (1) finding and recognizing the tough fibers of the flax stem; (2) spinning the fibers into long continuous threads; (3) fashioning the cords into a meshwork stout enough to arrest the plunging sharp-nosed fishes. Altogether considered, the evidence indicates that Stone Age men mastered fish biology in its practical aspects.

By far the greatest and most prominent monuments to early man's knowledge of aquatic animals

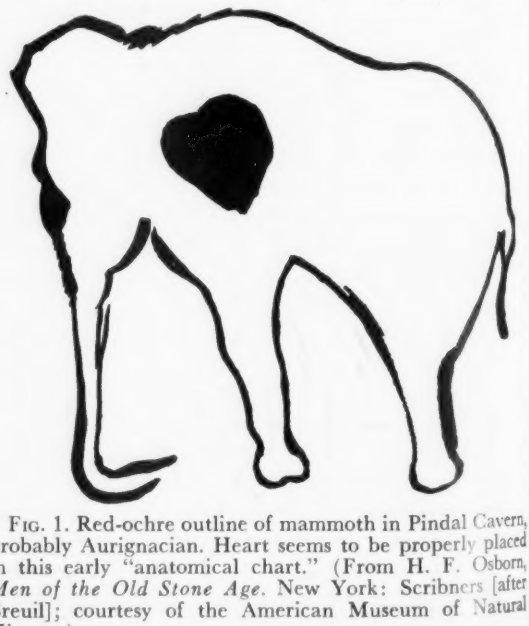


FIG. 1. Red-ochre outline of mammoth in Pindal Cavern, probably Aurignacian. Heart seems to be properly placed in this early "anatomical chart." (From H. F. Osborn, *Men of the Old Stone Age*. New York: Scribners [after Breuil]; courtesy of the American Museum of Natural History.)

FIG. 2. Section of a Danish shell heap showing accumulated household debris of many decades. Bones, pottery, and tools are quite common, but the bulk of such mounds is composed of mollusk shells. (After Madsen, courtesy National Museum, Copenhagen. From H. F. Cleland, *Our Prehistoric Ancestors.* © 1928 by Coward-McCann.)

are the shell heaps made by Neolithic groups in Denmark (Fig. 2). Others were being, or were to be, accumulated considerably later, in Japan, Ireland, England, and along the eastern and western seaboards of North America. Though the peoples concerned were widely separated in time and geography, they had in common an effective understanding of mollusks and their habits.

The size of the mounds, which the Danes call *Køkken Møddinger,* would indicate that mussels, scallops, oysters, and periwinkles were standard fare for many centuries.

Domestication of Animals

The first animal to be taken to man's heart and hearth was the dog. This friendship probably started in the late Paleolithic times. Certainly in Neolithic times we note that the dog was a constant domestic companion. His ubiquitous bones are found again and again, indicating that the friendship was extensive and enduring. Dogdom may have enjoyed the special favor of man for as long as 8,000 years, during which time the animal seems to have been carefully bred and selected. An Egyptian monument built about 5,000 years ago depicts a dog like the present-day greyhound, which we consider an extreme result of selection. As early as that time seven definite breeds were distinguishable.[7] Nor was the dog confined to Eurasia and Northern Africa: Columbus was barked at by two kinds when he visited the West Indies in the fifteenth century. Just when and how the first mutual confidence was established are matters of conjecture.

Even the genealogy of the dog is a moot question. Charles Darwin[7] quotes more than fifteen pages of opinions and claims regarding the origin of the dog. Some favor the jackal theory; others the wolf origin; and still others the "primitive dog" theory. The trials and difficulties of the adaptation are witheld from us by time, but the glaring fact stands out that unknown man of an unknown age, patient and wise in the ways of natural history, accomplished it.

It seems to be established that early Neolithic peoples of Denmark had already domesticated the dog, horse, ass, goat, pig, sheep, and bovine animals.[5] However, they remained partially dependent upon hunting and fishing. Their shell mounds contain the bones of the beaver, hedgehog, wild cat, polecat, ermine, weasel, otter, badger, and even the frog and the field mouse.

Time and controversial words shroud the origin of domestic cattle. There is no direct evidence that man consumed bovine milk as a liquid during the Stone ages. However, Swiss pile dwellings have disclosed churn parts and curd-processing equipment. It follows, then, that already in Neolithic times cows or goats, or perhaps both, were tractable milk producers. Cleland and others do not believe that the aurock, or any similar European animal form, was the immediate precursor of Neolithic dairy cows. There is evidence that the cow was domesticated as long as 10,000 years ago, and the hog only slightly more recently—both in Asia Minor. Sheep and goats have been herded for the past 8,000 years in that same region. And the camel may have been serving man in 6000 B. C.[1]

The implication is, then, that the well-known domestic animals of the Neolithic cultures in Europe were probably brought from Asia or Asia Minor.

Paleolithic man may have tamed the horse in Europe. The only evidence is one of his engravings of a horse's head, wearing what may have been a halter. The domestic cat has not been identified with the prehistoric cultures of Europe, but Egypt had given her an honored place in art thousands of years ago.

Trial, Error, and Accident as Vehicles of Progress

The last 20,000 years of man's prehistory saw more progress than the preceding 125,000 years. Ropemaking, weaving, agriculture, house-building, and many other advances were recorded in that more recent period. In general, hunting and fishing were abandoned as the main sources of livelihood. They were partly displaced by the more dependable results of farming and herding.

The human diet improved, too—not steadily, but from time to time beneficial eating habits were adopted, often without understanding but with the mere realization that the results were good. Several tribes and cultures inexplicably died out; inadequate diet could well have been one of the deleterious factors.

Before efficient transportation encouraged the distribution and exchange of foods, man ate what was at hand. Geographical limitations of plants and animals tended to force upon him the diet, good or bad, offered by his environment. Darwin[7] writes, "Dr. Hooker [nineteenth-century botanist] found the half-starved inhabitants of a village in Sikhim suffering greatly from having eaten arum roots . . . ;" and he adds that they ate many other injurious plants.

Sometimes man was fortunate enough, perhaps in a trial-and-error sort of way, to adopt supplemental materials he desperately needed. For instance, within historical times cod-liver oil was used for the treatment of rickets centuries before vitamin D was discovered. And English sailors ("limeys") sucked the juice of limes; Florentine druggists in the Middle Ages prepared and prescribed a kind of lemonade; both practices successfully combated scurvy centuries before vitamin C was known. As early as the thirteenth century goiter was treated with the residue of burned sponges; six centuries later Dumas discovered iodine, the active ingredient. Such hit-and-miss therapeutics were probably reaping benefits even in the Stone ages. The seaweed *Zostera marina* was used by the lake dwellers, perhaps for the production of salt.[6] Unknowingly, they were probably procuring iodine, ordinarily a dietary deficiency in that glaciated region of Europe.

Plants and plant products have been available for a long time. In fact, man has never been without them. Blackberries, strawberries, and blueberries existed a million years ago.[8] Perhaps early man was interested in a much different plant complement than we are today. To use our cereals and vegetables as standards may be somewhat misleading. De Candolle,[9] long an authority on the history of cultivated plants, writes that no useful plants were grown natively in South America, south of the Plata; nor in North America, north of Mexico; none in New Zealand or in Australia. Useful to *whom*? To us, obviously. Hooker, quoted by Darwin,[7] lists 107 species of Australian plants that are useful to the aborigines of that island, yet none is an economic plant according to our definition.

The origins of many important crop plants are lost in the vacuum of prehistory. About a century ago one authority[9] listed 157 of the most common cultivated plants, of which 85 were known in the wild state, and 40 were doubtfully linked with similar forms in the wild state; but 32 were unknown as wild plants, and their wild-plant genealogies were not even suggested.

Obviously, incipient agriculturists became breeders and selectors. The whole evolution of farming must have been a process of finding and perpetuating certain useful plant characteristics and modifying others. Given many thousands of years, man, even by trial and error and *per accidens*, could have effected many changes in cultivated plants.

The sugar beet, an extreme example, is the result of such a process in a modern setting over a brief period of time. About 200 years ago a German chemist recognized sugar in the cow beet and the table beet. Within sixty years of breeding and selecting, especially for sugar content, a new agricultural entity, the sugar beet, was born. It was, of course, an involved and expensive process. Before success was achieved the struggle invoked the royal sponsorship of the rivals Frederick William III of Prussia and Napoleon of France. Such acceleration was probably never duplicated in prehistory, but the point is that over a long period of time man could have influenced the characteristics of several plants that were important to him. Heer shows that the "grain and seed of our present varieties of wheat, barley, oats, peas, beans, lentils, and poppy, exceed in size those which were cultivated in Switzerland during the Neolithic and Bronze periods."[10]

Early man must have played an important part

in the distribution of plants, too, even before he domesticated them. California Indians used the seed beater and tray to collect wild seeds. By spilling seeds as they walked along through the patches of chosen, mature plants, beating the seeds toward the seed tray, they threshed and broadcast desirable seeds. This was purposeful propagation.[11]

American Indians caused, without a doubt, the dissemination of several American plants. Prairie crab apple, black walnut, buffalo berry, and wild plum seeds were evidently dispersed by the aborigines.[11] *Calamus,* or sweet flag, was particularly studied by Gilmore.[12] It was slowly moved from the Atlantic seaboard, step by step across the land, as the Indians transplanted its root. Sweet flag seldom blooms and never produces seeds, yet it is found growing even now in distinct patches in five Midwestern states.

The concentrated chicle forests of Yucatan probably were established by the negative efforts of prehistoric farmers.[11] Over a period of thousands of years the Maya Indians preserved the tree because of their high regard for its fruit, the nut. When land was cleared for agriculture these favored trees were allowed to stand. After a few years of cultivation the land was abandoned, and chicle trees filled in the open spaces because of the absence of competing trees. Evidently this interference with nature caused a preponderance of the tree in certain areas.

The Domestication of Plants

Man's major move to control the distribution of plants occurred when he assumed the guardianship of certain genera and species by planting, cultivating, and harvesting them. Although the scene of this important movement seems to be laid in Neolithic Europe,[7,13,14] at least one writer[1] believes that domestication first occurred in Asia. Metchnikov[15] associates early cultivation habits with the great rivers, Nile, Tigris, Euphrates, Ganges, Indus, Yangtze Kiang, and Hwang-Ho, whereas Vavilov[15] points to several great mountain areas as the loci of early plant domestication.

How tilling of the soil evolved in its early phases tempts the imagination. McCurdy[16] states it graphically when he says that perhaps the first tool was a stick, an extension of the finger; then the hoe and spade, extensions of the hand; this finally led to the plow, an extension of the foot—first drawn by woman, later by the ox.

Cereal grains. One modern writer[1] believes that cereal grains were being cultivated in Asia at least 10,000 years ago; another,[17] 6,000 years ago. There are various opinions[7,14,15] as to the number of varieties of wheat grown in Neolithic times in Europe, but they all agree that more than one variety was developed by Stone Age biologists.

Theophrastus (300 B. C.)[18] makes about fifty references to wheat, showing that it was very well established in his time. When and where those first few fistfuls were gathered and sowed we can never know, but the more than 5 billion bushels consumed annually in the world bear testimony to the good sense of prehistoric man.

Barley also dates back to the New Stone Age. In fact, it may have been the first domesticated grain.[1] All the earliest Egyptian mummies that were so examined had barley among their stomach contents. Although wheat, oats, and rye were notably absent, one in ten had millet seeds in his last undigested meal.

Oats may have been first cultivated in the Bronze Age, together with rye and another variety of wheat (*Triticum Spelta*).[7] Millet was found by Heer in the lake dwellings of Switzerland and is known to have been used ceremonially by Chinese emperors in "the third Millennium."[15]

Primitive man in America probably was 6,000 years behind the Old World in his Neolithic culture (sometimes called Heliolithic here), but it was he who gave corn to modern man. And only recently did contemporary civilizations acquire this grain. Corn is old; it seems to have had a long history of cultivation and selection before America was discovered. Indians of the upper Missouri Valley had 104 varieties. Four of them were sweet corn.[19] The ancestry of corn, in terms of its wild-plant progenitors, has not been established. Two Central American plants are suspiciously similar in one or more respects, but direct proof of derivation is lacking. The locale of its first domestication was Central America, probably Mexico.

The Aztecs, Incas, and Mayas were largely dependent upon it. The great Aztec civilization, destroyed by Cortez in the sixteenth century, devolved almost exclusively upon a corn economy. From the various Central American Indian tribes corn was traded or stolen valley by valley, century after century, spreading over the greater part of what is now the United States. When Columbus[20] reported his adventures to his royal sponsors he wrote that he had seen cornfields eighteen miles long (Fig. 3).

Potatoes. This vegetable has had an enviable history of travel and romance. Primitive man in South America found it growing wild, as indeed it still grows in the Peruvian Andes. He cultivated and improved it. The enterprising Spanish found several varieties when they visited, traded with,

and conquered the Incas. Then the Portuguese acquired it from Spain. Thence it was taken to Italy, Austria, Germany, Switzerland, and France, literally growing underground across Europe.

Drake, a bold and notorious pirate to her majesty Queen Elizabeth, snatched the curious tuber from the plundered stores of a Spanish ship and carried it to England. Finally, in 1586, the "Irish" potato reached Ireland. About 1719 it was brought to North America by immigrants.[21]

Peas and beans. Small-seeded peas were found by Heer[14] on several occasions in the homesites of prehistoric agriculturists. He supposed that they were common dietary items during the New Stone and Bronze ages. After that they faded into extinction. The same investigator found small-seeded beans left by civilizations from the Bronze Age to Roman times. In either case, smallness of the seeds is significant, suggesting their recent departure from the wild forms. The broad bean is an antique in the civilizations of prehistoric South America, but the soybean is much older. Shen Nung, a Chinese emperor, in 2838 B. C. described it in a book on plants, one of the earliest of botany books.[22]

So the story of primitive agriculture goes: clear, startling paragraphs here and there, and frustrating hiatuses interposed among them to prevent the complete unfolding of the story.

Fruits. The lower basin of the Tigris and Euphrates, the traditional site of the Garden of Eden, probably was the first home of the cherished date palm. This was 6,000–8,000 years ago.[23] And there was more than passivity to this prehistoric crop production: Babylonian and Assyrian monuments depict pollination ceremonies that indicate a basic understanding of plant sexes at that time. The King of Assyria, Ashurnasirpal, in early historic times is shown in a bas-relief pollinating a symbolic tree, accompanied by winged priests. Herodotus[24] describes the process of hand pollination as practiced by Egyptians to insure a maximum crop of dates.

The persimmon was under cultivation 4,000 years ago in the Orient. Oranges seem to have been developed much later, but a twelfth-Century Chinese monograph[25] on the subject lists a total of twenty-seven standard varieties at that early date.

The wild, hard apple, small and acid, came from the thickets of Western Asia and temperate Europe. Stone and Bronze Age men pounced upon desirable mutations, even as we do now, to establish trees with larger and juicier fruits. Refuse heaps of the Bronze Age[14] and of the Stone Age[7] contain wild crab apples—whole, halved, and quartered—now carbonized. Plum stones, rose hips, and elderberry seeds were also found among the debris of the Stone Age of Switzerland. It does not follow, however, that they were cultivated.

The grape must have been a favorite during much of the latter prehistoric period. Bronze Age

FIG. 3. An Aztec urn bearing excellent reproductions of ears of corn. Note dented kernels like those of many modern varieties. (After Kempton, courtesy W. E. Stafford; USDA photograph.)

deposits of Switzerland and Italy contain seeds readily identified as those of the grape. Nor was the fruit confined to Europe; seeds have been reported in Egyptian tombs.[26]

Fiber-producing plants. The origin of cultivated flax is probably traceable to two loci.[15] Besides the ordinary flax seeds that have been found in various Stone Age excavations in Europe, there is the large-seeded variety peculiar to the Egyptian excavations. The seed in either case was used for food, and the stem fibers were spun and woven into fabric. Neolithic remains in Switzerland contain fragments of such linen cloth.

Cotton probably had two origins: it was domesticated in historical times in the Old World[27] and prehistorically in tropical America. Hemp is much older than cotton, but not so old as flax. It was probably introduced into Europe from China about 1500 B. C. Herodotus says that up to 484 B. C. hemp was not known to the Greeks and Romans, but Pliny, Columella, Varro, and Dioscordes all had written about the use of its tough fibers.[15] Even though it is not mentioned in the Bible, it must have been important in the Mediterranean area after it was finally introduced there.

Miscellaneous vegetables. Several of our honored vegetables were chosen from the wild-plant population before history was written. The mustard family, with its cabbage, kale, and collards, is very old in the human diet. Various members of it are mentioned by Pliny and Theophrastus. Wild cabbage is still gathered and eaten in southwestern Europe, as it was 4,000 years ago.[28] Cucumbers were originally tamed in ancient Egypt and later cultivated by the Greeks and Romans. An attractive cousin, the watermelon, is probably much older. Ancient Sanskrit writings describe it as a native of Africa, where it probably originated. The pumpkin was domesticated by primitive basket-making peoples in Central America[29] before the advent of cliff dwelling.

The onion, perhaps derived from wild stock more than 4,000 years ago, has been cultivated so long that its wild precursor no longer is known.[27] Israelites and Egyptians of prehistory used this bulb, one of the few edible bulb-producing plants. Other varieties seem to have arisen independently in China and western Asia.[30]

Lettuce is referred to as a common garden plant by Greek and Roman writers. The several hundred varieties grown at present seem to have come from the wild lettuce of India and Central Asia.[29] The transition from the wild to the domesticated forms does not appear to be great, yet the head-producing varieties offer some extremes in genetic vagaries.

Medicine

Even since the first cry of human pain pierced the quiet of the eolithic forest man has attempted to alleviate his own and the suffering of his fellowmen. Because his life was outdoor and rugged he suffered frequent accidents, but his most mysterious enemy, that timeless slayer of men, the microorganism, was already at work. In fact, the bacterium antedated man by thousands of centuries. Lower animals suffered from the attacks of bacterial diseases millions of years ago. This is borne out by certain fossil studies. Chronic osteomyelitis of the spine left its traces on the skeleton of a Permian reptile, Demitridon.[31] That case in subhuman pathology was closed about 240 million years ago. During the same period carious teeth were developing in primitive fishes.[16] Auer describes the results of an infection of the pelvis of a Jurassic crocodile of perhaps 125 million years ago.[31]

When man arrived bacterial diseases were literally waiting for him. The remnants of Stone Age man's skeletons still bear structural abnormalities caused by pyorrhea alveolaris[16] and the spine-crippling spondylitis deformans and knee arthritis.[31]

There is little reason to believe that Paleolithic or Neolithic medicine men could do anything directly to help their patients suffering from bacterial diseases except by that important psychological lift which has passed from healers of all ages to the patients of all times. We can only conjecture what activity may have gone on behind the supraorbital ridges of a Mousterian medicine man's skull, but by examining the 50,000-year-old bones of Europe's pioneers we can learn that a good percentage of the fractures were restored.[32] Someone aided the victim when he fell from a cliff or was gored by a bison. That medicine man knew some of the fundamentals of osteology. If he was good, and the type of accident was repeated, he soon became a "specialist." Hunting, fighting, and tool-making duties became lighter for him.

Specialists went far beyond setting bones as they tampered with the living skeletons of friends, neighbors, and clansmen. Their most astounding surgical performance was trepanning, the removal of a small disk of skull bone. Several other visceral incisions and excisions may have been common practice, too, but the nature of the soft parts of the body does not lend them to preservation. No doubt some cranial "knotholes" were cut into skulls after death, and the removed bone became an amulet to be suspended from the neck on a leather cord. Good fortune or strength was assured the wearer because the skull belonged to a "charmed" person,

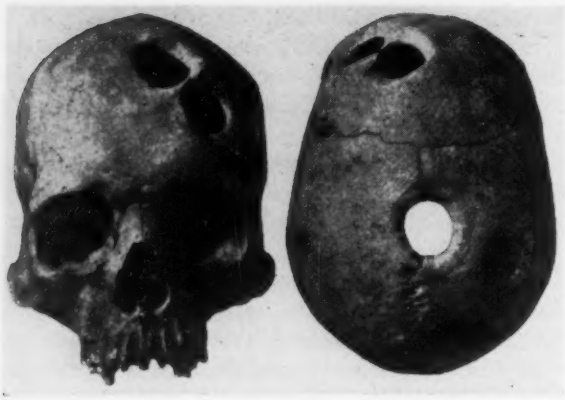


FIG. 4. Two views of an Inca skull, from the Peruvian highlands, showing five healed wounds of trepanation. (After G. G. MacCurdy, courtesy Dr. Brew, Peabody Museum.)

or a powerful enemy, or a favorite relative. That type of trepanation is easily recognized because the edges of the opening remain sharp. When, however, an inch-and-a-half disk of cranium was removed from a living subject, and he survived, the edges of the opening became completely cicatrized.

Some "patients" were trepanned as often as five times (Fig.4): the patient (and "patient" is very appropriate here) recovered from each crisis, and the bone healed. Eighteen per cent of 250 ancient skulls collected from Peru were trepanned.[16] The practice was more widespread than one would suppose when we consider the skill required of the operator, the crude stone instruments available, and the pain experienced by the victim. Trepanned skulls have been found in America, Algeria, Denmark, and Neolithic France.[5]

MacCurdy[16] believes that the first operation was performed to relieve the pressure of a depressed fracture. Since the unrelieved victim fought and threshed much as do sufferers from certain mental diseases, the opening seemed to let out the evil spirit—the supposed cause of the unrest. Any unfortunate flint-chipper who persisted in his dementia acquired more and more holes in his head as the early practitioners stuck to this diagnosis and prescription.

Art

Man is, and always seems to have been, an irrepressible writer. Before he possessed words and letters he employed drawing, engraving, and sculpturing to state his ideas and declare his interests. Looking over the chasm of scores of thousands of years, we are not always sure of his motives when he set his hand to transcribing his mental pictures. Was it awe and fear that drove him to depict the mammoth? Did he gain courage by tracing and retracing the bison before the hunt? Or was his aesthetic sense actually aroused by the forms and figures of things about him?

Magdalenian artists represented more than thirty mammals in their art, yet birds, fishes, and reptiles were rarely subjects. Furthermore, the beauty of the plants surrounding them left them cold. Ever since man has been accused of being an aesthete his brush and pen have been moved to stratospheric heights of ecstacy by flowers, fruits, trees, sunsets, and clouds. Not so with the men of the Stone ages; their motivations were different, perhaps as simple as this: their needs were biological and basic; their pleasures and satisfactions were equally basic, most often gustatorial—hence their art interest was usually allied to food objects of particular value.

We need not belabor the word "art" to make it accommodate the work of prehistoric artists. The polychromatic bison and wolf painted on a Magdalenian cave wall are works of refined beauty by the standards of any age. Graceful and lifelike is the wild horse mural in a Dordogne cave in France. The early Aurignacian worker who executed it was truly an artist. That was 25,000 years ago, and the cave was dark. Only the mind of the painter was in full light. On the same walls of Font-de-Gaume at Dordogne were the figures of ibex, cave bear, reindeer, woolly rhinoceros, and wild cattle, all in fine artistry. In the famous Altamira Cave an unknown artist illustrated movement in a wild boar by showing two sets of legs in different positions. Until that discovery the Italian painter Balla was believed to be the first to represent animal motility by painting multiple sets of legs on a dog.[33] The nameless man at Altamira, however, working perhaps 250 centuries earlier, deserves the honor of priority.

Elsewhere and elsewise there have been paintings, engravings, and carvings on stone, bone, and horn. The chamois, lion, stag, hare, fish, bear, wild goat, serpent, swan, duck, and grouse have been represented.[34] There were degrees of excellence; not all were of high artistry.

Perhaps one doubts the fidelity of some of the paintings, particularly of animals no longer extant. One fine substantiation is offered by a quirk of Mother Nature when she froze the mammoth in his tracks, preserved in Siberian ice. So well preserved was one specimen that an undigested meal still in its stomach was identified after a hundred centuries as *Ranunculus acer* (a buttercup), sedges, grasses, the beans of wild oxytropis, and young shoots of fir and pine. At least one good specimen of the woolly mammoth is preserved and mounted in a Russian museum. The point is that it looks

exactly like the painting executed by artists of the Old Stone Age.

The biologists who turned to art in Paleolithic times had strong zoological leanings. More specifically, they were vertebrate zoologists. One of the rare botanical outbursts resulted in the graceful outlines of a branch with alternate leaves carved on bone; another shows a tuft of long grass beside a browsing reindeer. The invertebrate animals were in disfavor. Only five specimens are reported; four of them are beetles.[16]

The human body is sometimes depicted as a runner or a hunter in action, but the figures are no better than childish cartoons. The human hand has been traced several times, but these crudities show neither anatomical subtleties nor natural positions of relaxed fingers.

Hosts of lacunae prevent us from fully evaluating the primitive biologist. There exists a whole field of experiences, biological in their substance, mystical in their lack of resolution, which must have frustrated early man. The poignant problems of conception, gestation, birth, life, growth, senescence, disease, and death, many of which still baffle us, must have engendered mysticism, superstition, and fear in the hearts of primitive men. They could forget those problems, however, in the face of more demanding ones involving survival. Their interest in the biological world was definitely of a practical cast.

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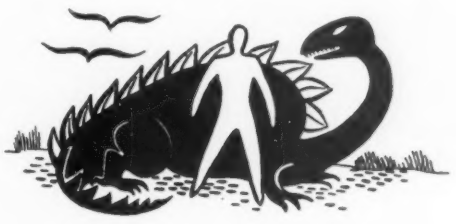


Early Work of the National Bureau of Standards*

LYMAN J. BRIGGS

The career of Dr. Briggs, director emeritus of the National Bureau of Standards, is so well known as to make an account of the details almost superfluous. Detailed to NBS from the Bureau of Plant Industry during World War I, he served successively as chief of the division of Mechanics and Sound, assistant director, and as director 1933 to 1945. Among his many achievements are the artificial horizon for use on battleships and the earth inductor compass for airplanes. He has done a great deal of research also on the absorption of water vapor by quartz, the mechanics of soil moisture, characteristics of air foils and projectiles at speeds approaching the speed of sound, acceleration of gravity, and the properties of liquids under negative pressures. With Paul Heyl he received the Magellan medal in 1922, and the Medal for Merit in 1948.

THE National Academy of Sciences, at its meeting in Washington in 1900, passed the following resolution:

WHEREAS, The facilities at the disposal of the Government and of the scientific men of the country for the standardization of apparatus used in scientific research and in the arts are now either absent or entirely inadequate, so that it becomes necessary in most instances to send such apparatus abroad for comparison: Therefore, be it *Resolved*, That the National Academy of Sciences approves the movement now on foot for the establishment of a national bureau for the standardization of scientific apparatus.

Strong endorsements were also sent to Congress by the American Chemical Society, the new American Physical Society, the American Institute of Electrical Engineers, and by the country's leading physicists, chemists, and engineers. There was no dissenting voice.

At that time the Office of Weights and Measures, under the Coast and Geodetic Survey, had the custody of the standards of length, mass, and capacity. One of the ablest proponents of the new Bureau of Standards, which meant the transfer of the Office of Weights and Measures, was none other than Henry S. Pritchett, the superintendent of the Coast and Geodetic Survey. The members of the Congressional committee were much intrigued by Dr. Pritchett's testimony. Here was a bureau chief who was actually proposing to give something up!

When a Congressman pointed out that the $6,000 salary proposed for the director was only $2,000 below that of a cabinet member, Mr. Gage, then secretary of the treasury, replied: "Almost anybody will do for the secretary of the treasury. It takes a high-grade man to be chief of a bureau like this." Nevertheless, when the bill was reported out of committee the director's salary was fixed at $5,000. This was as much as a Congressman got. What rational being could expect more?

So in the closing hours of the Congress on March 2, 1901 the National Bureau of Standards was established, and S. W. Stratton was appointed director.

In 1903, the secretary of the Department of Commerce and Labor directed that the word "National" be dropped from the bureau's name. But as the years went by this lack of a distinctive title came back to plague us. New bureaus of standards began to spring up, in state governments, in chambers of commerce, in department stores. We were being credited with extraordinary indorsements of questionable products. In 1935, the secretary of commerce finally agreed with me that our original name, National Bureau of Standards (NBS for short), should be restored.

The first appropriation is of some interest. The total provided for salaries was about $27,000, together with $10,000 for equipment. Fortunately, $250,000 was authorized for constructing a laboratory, and $25,000 for the purchase of the first eight acres of the present site, which by painful accretions has now grown to seventy-two acres. For some years, cow pastures adjoined the bureau grounds, but now the city has flowed out beyond it for many miles.

The bureau was charged by law with the custody

* Based on an address before the National Academy of Sciences, April 25, 1951.

and construction of standards and their use in fixing the value of standards submitted by universities and other groups, with the testing and calibration of standard measuring apparatus, and with the determination of physical constants and the properties of materials.

Obviously, the first and immediate task of the new NBS was to establish its own working standards. I shall have to limit myself to the primary electrical standards as examples. The volt, ohm, and ampere are precisely *defined* in absolute measure, that is, in centimeter, gram, second units. But to *establish* these quantities in absolute measure was a Herculean task. An earlier International Electrical Congress had sought to define these units in a way that could be more easily realized. The ampere was defined by the rate of deposition of silver, the ohm as the resistance of a specified column of mercury, and the volt as a specified fraction of the electromotive force of a certain type of standard cell. But the standards set up by the various national laboratories in accordance with these definitions did not show the accord that had been hoped for. In 1910, therefore, representatives of the physical laboratories of England, France, and Germany came to Washington, bringing with them their standard resistors and standard cells. A long and painstaking series of intercomparisons was made, and complete agreement on the international electrical units was reached. A fixed value was assigned to each standard resistor and cell from each country in terms of these international units. At last the national laboratories were in complete accord as to their electrical standards.

But not for long. The standard resistances and cells slowly began to drift, and by 1925 there were again serious discrepancies among the standards of the various national laboratories. Once more something had to be done. By international agreement it was decided to undertake, once and for all, the establishment of the ohm and the ampere in absolute measure, that is, by measurements involving only the fundamental standards of length, mass, and time. An illustration may help to clarify the method of procedure.

Let us say we wish to establish the ampere, the unit of current. Suppose we have a flat circular coil of wire suspended horizontally from the end of the beam of a sensitive chemical balance, and counterbalanced by weights on the opposite pan. Let this coil be surrounded symmetrically above and below by two similar but larger horizontal coils, which are fixed in position. If now a current is passed through these three coils in series, a pull is exerted on the suspended coil through the interaction of the magnetic fields. We now calculate laboriously from the dimensions and positions of the three coils what this force would be if a current of one ampere were flowing through the coils. We place additional weights equivalent to this force on the scale pan. If our calculations are correct, then the current flowing through the coils when the beam is in balance is exactly one absolute ampere.

A current balance of this type was first used at the National Bureau of Standards by Rosa, Dorsey, and Miller in 1911. When the international decision was reached to establish the electrical units in absolute terms, further measurements were made by H. L. and R. W. Curtis and Critchfield, using new coils whose dimensions could be measured more accurately. The final value agreed to within 20 ppm with that determined at the National Physical Laboratory in England, using another type of current balance.

Measurements of this kind require an exact knowledge of the pull of the earth on the balancing mass in the scale pan. In other words, the *absolute* acceleration of gravity at the NBS must be accurately known. This has been measured by Paul Heyl, using fused quartz reversible pendulums. In another investigation Heyl measured the gravitational constant—that is, the attractive force between two spheres, each having a mass of one gram, when their centers are 1 cm apart. Knowing these two constants, the mass of the earth can at once be computed.

The national standards of mass and length. Distance between two parallel lines engraved on the platinum iridium bar, which is kept at the NBS, is the primary standard meter for all measurements of length in the United States. Likewise, the platinum-iridium cylinder, which is also kept at NBS, is the primary standard kilogram for this country.

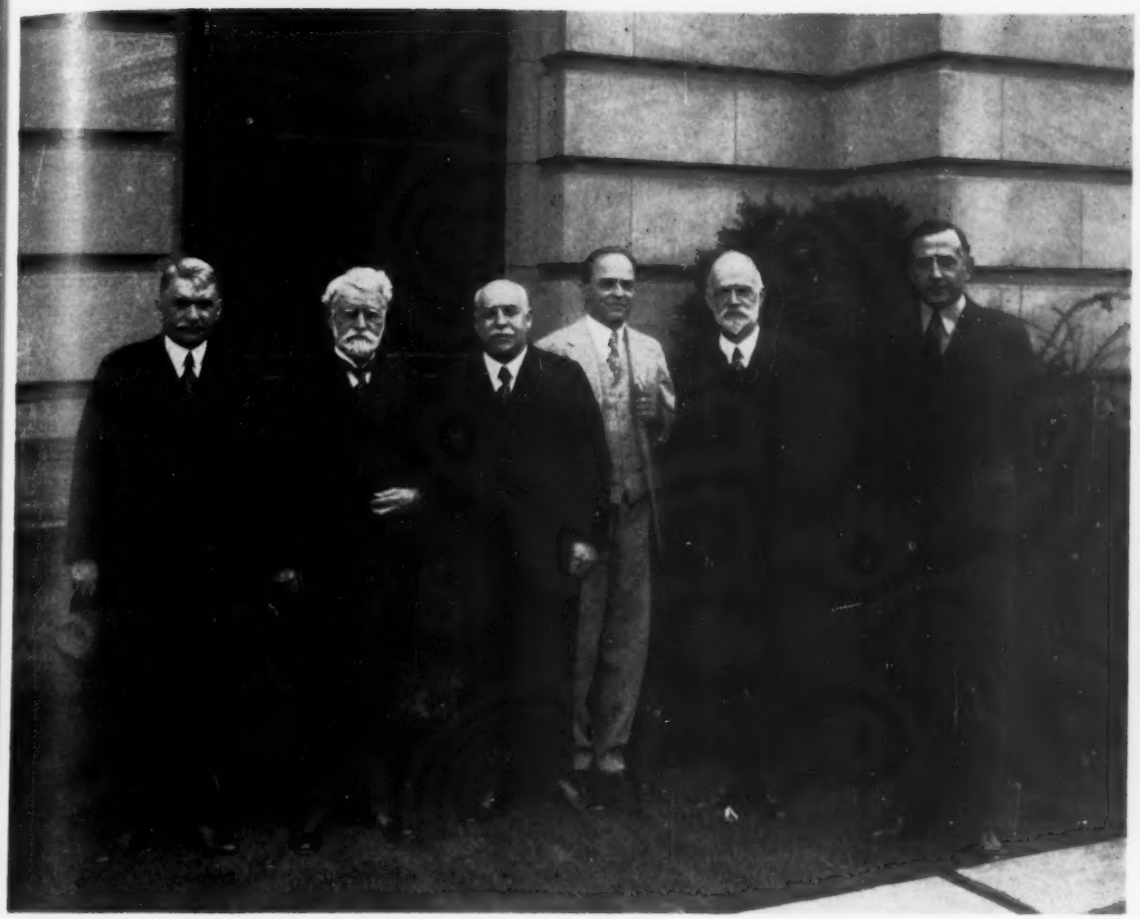
Measurements with the current balance established one of the electrical standards. But it was also necessary to establish the ohm. This involved an immense amount of work, extending over more than a decade. The problem was approached in two different ways at the bureau. Curtis, Moon, and Sparks used a standard of self-inductance. Wenner, Thomas, Peterson, Cooter, and Kotter employed a standard of mutual inductance. Extreme care and infinite patience were required in constructing and measuring these inductance standards, because from their physical dimensions their absolute value was calculated.

As in the case of the ampere, the NBS determinations of the absolute ohm were combined with those of other national laboratories to establish the new world-wide standard. The new standards were to have been adopted internationally in 1940, but the outbreak of the war prevented such action. Happily Dr. Condon has recently secured Congressional legislation putting them into effect. This is assuredly one of the great accomplishments of the National Bureau of Standards when we compare the present situation with the one fifty years ago.

Another early determination at the National Bureau of Standards was the ratio of the electromagnetic to the electrostatic unit of electricity. According to the classical theory of Maxwell, this ratio is numerically equal to the velocity of light. The value obtained by Rosa and Dorsey, when the resistances they used are expressed in absolute units, was 29,979 km/sec. Up to five years ago, the generally accepted value for the velocity of light was 29,977 km/sec. But recent measurements by the microwave cavity method and by Shoran give 29,979.0 km/sec, in accord with Rosa and Dorsey's value.

It is often the experience of laboratory workers that during the course of an investigation something unexpected (and troublesome) turns up that leads eventually to results as far-reaching in importance as the original investigation. This was true in the work just mentioned. Rosa and Dorsey

The equisignal aircraft radio range, now in general use by all commercial airline pilots to guide their craft along the air routes, was first set up and tested in the United States at NBS in 1921. Photograph shows the original dual-coil antenna system used at the bureau to produce the on-course equisignal zone in space.



The NBS visiting committee in 1926. The committee was established by law "to visit the Bureau at least once a year and to report to the Secretary of Commerce upon the efficiency of its scientific work and the condition of its equipment." Left to right: S. W. Stratton, director of NBS 1901–22, then president of MIT; Ambrose Swasey, founder of the firm of Warner & Swasey; G. K. Burgess, director of NBS; W. R. Whitney, director of research, General Electric Corporation; W. F. Durand, professor of mechanical engineering, Leland Stanford University and president of the American Society of Mechanical Engineers; and Gano Dunn, president of J. G. White & Co.

found that their standard resistance coils, immersed in oil, went through an annual periodic change in resistance. This was traced to the absorption of minute amounts of water by the oil during the humid summer months. This led at once to the use of sealed coils and finally to coils of remarkable constancy developed by Thomas, in which the wire is first preformed and annealed at high temperature (500° C) on a mandrel before being hermetically sealed. The bank of ten such 1-ohm coils now used to represent the absolute ohm shows an internal consistency of 1 part in a million or better. What is even more important, measurements made over a ten-year period with the mutual inductor previously mentioned show no drift of the group as a whole, within the limits of measurement.

The volt is derived from the absolute ohm and ampere by Ohm's law. It is maintained during the period between absolute measurements by a selected group of standard cells, some of which have been in the reference group for forty years. Each member of this group is occasionally compared with one selected as a temporary reference standard. If any cell shows signs of deterioration, it is replaced by another whose performance is known. The group as a whole has been found to remain constant to 1 part in a million or better over long periods. This group of cells and the group of 1-ohm coils together constitute the NBS reference standards. Another derived unit is that of capacitance, which Moon and Sparks have established, to a part in 100,000, using the self-inductor and the absolute ohm.

With the outbreak of World War I, the bureau devoted itself to war activities. The Army and Navy quickly realized the advantage of being able to call upon a well-equipped laboratory with a staff

This Curtiss Fledgling, equipped in 1931 with the first complete system for blind landing of aircraft, demonstrated the practicability of the system by an extensive series of hooded landings at College Park, Md., and Newark, N. J. The dual-pointer landing indicator on the instrument panel gave the pilot a visual indication of his position in space with respect to the proper approach glide path. Adopted and adapted by the CAA, this NBS radio instrument-landing system is basic to the present universally used ILS blind landing system.

of trained men, and the bureau was flooded with requests for assistance. This led to marked advances in radio, optical, and aeronautical instruments; to the construction of an altitude laboratory for studying the performance of aircraft engines under reduced pressure; to the building of a wind tunnel for the study of the characteristics of air foils and the calibration of air-speed meters; and to countless tests of the properties of materials.

A most important part of this program was the standardization of screw threads and the measurement and certification of master gauges for screw threads. This was of such industrial as well as military importance that Congress in 1918 established the National Screw-Thread Commission, in which work the NBS took a leading part. But in 1933 the incoming Congress ridiculed this commission and abolished it as a useless government activity. I advised the secretary of commerce that this action froze the existing screw-thread standards for all time, making additional improvements impossible. The project was then quietly re-established by executive order, under the name of the Interdepartmental Screw-Thread Committee, which continues to this day.

The screw-thread standards of England and the United States were different. This led to grievous delays and great and needless expense in the conduct of World War II. For example, standard equipment from the United States carrying threaded outlets would not fit the mating part on British planes. The over-all loss has been estimated at over $100,000,000. An intensive effort was therefore made during and after the war to bring the standards into agreement. Two years ago Dr. Condon, as chairman of the Interdepartmental Screw-Thread Committee, was one of the signers of a Declaration of Accord, unifying the screw threads of Canada, the United Kingdom, and the United States. Not only is this agreement of great military importance, but it will do much to facilitate and promote the export trade of these nations.

The term "standard" is not defined in the organic act establishing the National Bureau of Standards. The founders apparently had primarily in mind basic laboratory standards. A need soon arose, however, for standards of quality and performance which, if they were to be established by the bureau, would require legislative action. Many manufacturers opposed such action on the ground that it would stifle initiative, so nothing was done. In fact, the viewpoint of many manufacturers in those early days reflected that of the schoolboy who, when asked to define a standard, said it was something to hold up a "STOP" sign.

Perhaps it was just as well that the NBS did not embark upon the official establishment of standards of quality and performance. The same result has been arrived at by the more democratic method of common agreement, although at times this process has been painfully slow and discouraging. Nevertheless, the bureau has given much time and effort to establishing standards of quality and performance. The American Standards Association was founded by the national engineering societies in 1918. NBS men have contributed to the development of half the standards promulgated by this association; they have worked extensively with the American Society for Testing Materials in developing testing methods; and they have taken a very active part in the preparation of federal specifications, under which the government makes purchases through competitive bids. An immense amount of laboratory work in determining the facts regarding a product upon which a specification or standard can be based is involved.

Furthermore, the National Bureau of Standards has developed a most helpful series of standard samples, covering alloy steels and other metals of known composition, certain chemicals of great purity, radium standards, thermocouple standards, and others. Some 20,000 of these standard samples are sold annually at cost and are of great value in analytical research work.

Dr. Stratton, who had directed the work of the bureau so successfully from its beginning, resigned in 1923 to become president of the Massachusetts Institute of Technology. He was succeeded by G. K. Burgess, chief of the Division of Metallurgy and a talented experimental physicist who had been a member of the bureau staff since 1903. The secretary of commerce at that time was Herbert

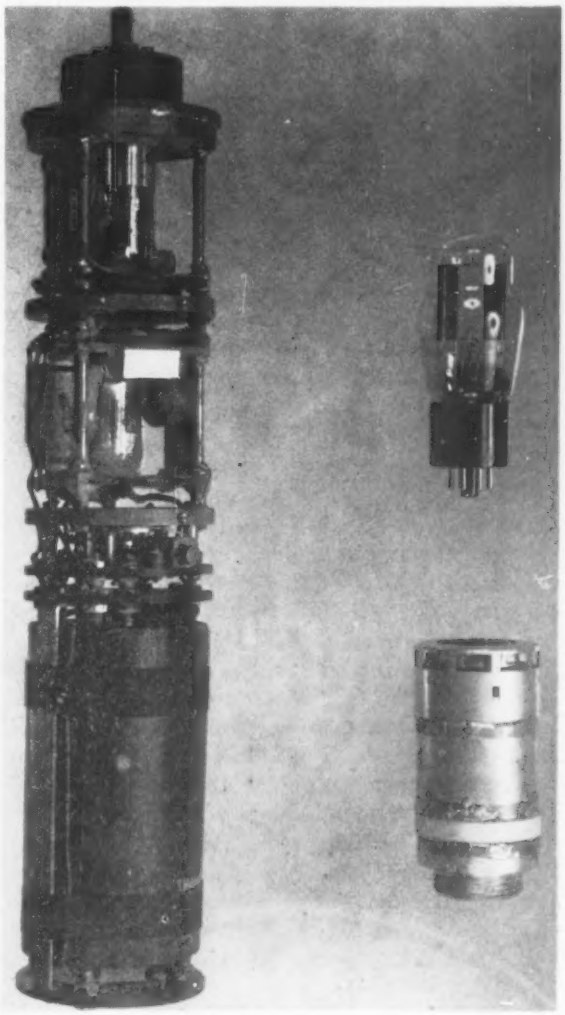
Hoover, who believed in the value of scientific research, and effectively supported our work. It was an era of great activity and development for the NBS.

For the Civil Aeronautics Authority, the Bureau took a leading part in the design and development of radio ranges and radio beacons for the safe guidance of airplanes to landing fields. As early as 1931 the bureau invented instruments and equipped an airplane for making blind landings. One day, when the whole Eastern seaboard was covered with a fog so dense that all planes were grounded, an NBS man took off from our flying field at College Park, Maryland, and, with only radio aids to guide him, landed smoothly in a smother of fog at the Newark, New Jersey, airport. Features of the system used are incorporated in the blind landing systems used today.

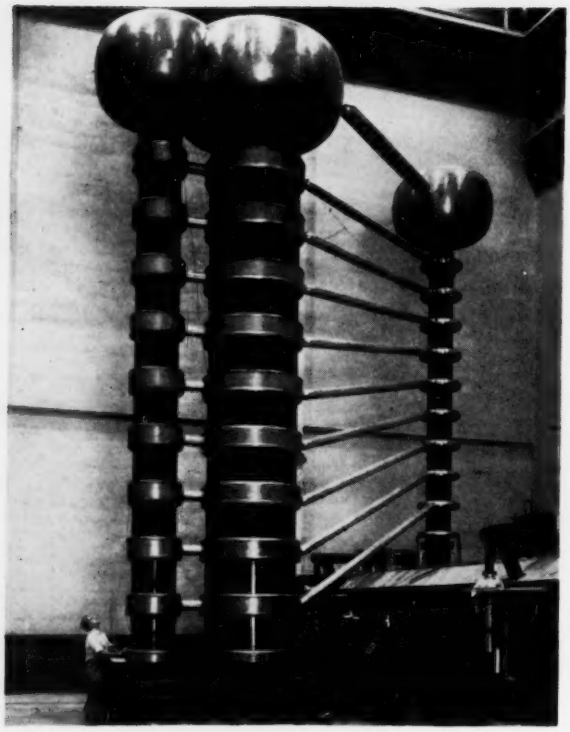
The bureau also made extensive tests for the CAA of the reliability and performance of commercial aircraft engines, and carried out pioneer work on the soundproofing of airplanes. This latter work was but part of a continuing investigation at the bureau of the effectiveness of sound-absorbing building materials and of types of construction that reduce the transmission of sound.

The untimely death of Dr. Burgess at his desk, in July 1932, ended a career of great service to his country. My own responsibility for directing the bureau's work thus began in the depths of the depression and ended with the close of World War II. The first act of the incoming Roosevelt administration was summarily to reduce, by one half, the appropriations of the government scientific bureaus. History shows that the promised economies of the new administration did not go much beyond this point. It was a bitter experience for us. More than one third of our staff was dropped on a month's notice. My own feelings were reflected exactly in the story of the Londoner in a historical pageant put on during a hot summer day to help take the minds of England's unemployed away from their troubles: As the procession came to a halt in front of two visiting Americans, one of them said, "I believe this man in front of us is supposed to be Appius Claudius." "But he's dressed as a Roman soldier," said his companion. "Appius Claudius was a road-builder, a great engineer." "I know," said the first, "but he liked to dress as a warrior. Let's ask the man." So he said, "Pardon me, but are you Appius Claudius?" "No," said the man. "I'm un'appy as 'ell."

But we carried on. The work on the absolute electrical standards was completed. The thermodynamic properties of saturated steam, so important in the design of steam turbines, were precisely measured up to the critical region. Heavy water was prepared for the first time. Extensive studies were made of the effect of certain changes in the ionosphere on radio communication. Sunspots were found to produce radio blackouts. The radiosonde was developed for making meteorological measurements up to 60,000 feet or more. Carried by a small balloon, this little instrument radios back in code the temperature, pressure, and humidity of the air as it ascends. It is now used daily by the Weather Bureau at many stations.



Left, first successful radio proximity fuse in the world, constructed by NBS and tested by bureau scientists at the Navy Dahlgren Proving Grounds on February 12, 1941, less than two months after the initiation of the fuse program. The later generator-powered proximity fuse (lower right) shows much greater reduction in size. Note conventional radio tube (upper right) for size comparison. The proximity fuse was acclaimed as the second-greatest scientific achievement (the A-bomb was first) of World War II.



High voltage X-ray installation—largest of its kind in the world—at NBS. These towering generators are used in a broad program of X-ray research. Important problems investigated include development of effective and economic barriers to safeguard those engaged in medical and industrial applications of X-rays, design of X-ray instruments, development of measurement techniques, establishment of X-ray standards, and calibration of X-ray dosage meters.

Radiation standards were established, including a standard of brightness, which was later adopted internationally. The light emitted from one sq cm of a perfect radiator at the temperature of freezing platinum is defined as equal to 60 candles. This standard was made possible by the discovery at the NBS of a way to make crucibles of thoria, in which pure platinum can be melted without contamination.

Then came the defense program and World War II. It was suddenly not a question of funds, but of men. Again, the bureau's experienced staff of physicists, chemists, metallurgists, and engineers was called upon by the armed services to direct work on countless problems, particularly in the development of new weapons.

In October 1939 President Roosevelt appointed the director of the bureau as chairman of a committee to investigate the possibilities of uranium fission in warfare. The outcome is too well known to need elaboration here. I only wish to say that bureau men contributed substantially to this investigation, and shall mention but two instances.

Uranium, as recovered from the ore, contains many other elements. Some of these are very active in capturing neutrons. Their presence in uranium would consequently greatly increase the size and cost of an atomic pile, or even prevent the chain reaction from taking place. By utilizing an odd property of uranium nitrate—namely, that it is very soluble in ether—Hoffman of the NBS was able to precipitate out and remove, practically completely, the impurities that were proving so troublesome. Within a month, this process was being used to purify uranium in half-ton lots.

Again, the graphite first used in the atomic pile experiments was found to contain boron, which is a strong absorber of neutrons. Its presence in the graphite would have prevented a chain reaction. Rodden and other NBS men patiently checked, with a spectroscope, the various steps in the manufacture of graphite bars. The source of the boron was discovered and eliminated.

Early in the war, an allied attack by airplanes was jeopardized by a radio blackout. Planes lost their direction and some failed to get home. The armed serves asked the NBS to make both daily and long-range forecasts of conditions determining radio communication—"radio weather." So successful was this work that it was established at the end of the war as a permanent NBS activity.

The first world war cut off the supply of optical glass to the United States. The Geophysical Laboratory of the Carnegie Institution, and the bureau, undertook the establishment of this new industry in this country. In the interval between the two wars the NBS optical glass plant, supported by Navy funds, supplied all the Navy's requirements. Much was learned during this period about the production of optical glass of high quality, with predetermined indices of refraction and dispersion.

When war was again declared, the bureau and the Bausch & Lomb Optical Co. were the only sources of optical glass in the United States. As the demand increased, the bureau opened its plant for the training of men sent by other companies to learn the art of making optical glass, including groups from Canada and Australia. Our own plant was again enlarged, and during the war we supplied the Navy and Army with nearly a million pounds of optical glass of the highest quality, molded into the form of prisms or lenses so that a minimum amount of grinding was necessary in finishing the pieces. At no time were the armed services held up for lack of optical glass.

The proximity fuse was a remarkable war development. It explodes its shell or rocket or bomb if it comes near its target. The fuse does not need to

strike the target. This makes it an extremely effective weapon against aircraft or against troops in the open or in foxholes. Although the fuse is small enough to be covered by a man's hand, it is in effect a complete radio sending and receiving set. It picks up its own signal as it is reflected back from the target, and when this reflected signal becomes strong enough, the projectile is exploded.

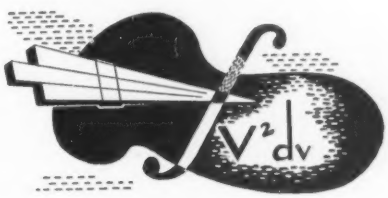
There were two developments of the proximity fuse. One was for use with rapidly spinning projectiles fired from large guns, and was carried out under the direction of M. A. Tuve, of the Carnegie Institution, for the Navy. This fuse was armed by utilizing the spin of the projectile and proved to be very effective in shooting down V-1 rockets as they crossed the English Channel, and against Japanese attacks by air.

The other development was a proximity fuse for use on bombs and rockets and other nonspinning projectiles. This work was done at the NBS under the direction of Diamond, with the cooperation of the NDRC and the Army. The arming (safety catch released) of such a fuse presented special problems. It was used to great advantage at Iwo Jima and in other campaigns against the Japanese. It proved to be from ten to twenty times as effective against troops in foxholes as an ordinary fuse. It explodes the charge well above the foxholes and the fragments come showering down. The War Department provided the bureau with a new laboratory to continue developments in this field.

Another new weapon was the guided missile the Bat, developed at the bureau by Dryden and his associates with the cooperation of the Navy, MIT, and the Bell Laboratories. This flying missile is launched from an airplane. The name suggests the principle on which it operates. Live bats give out a short pulse of sound and guide themselves by the echo. The Bat emits short-wave electrical pulses and is directed to its target by radar echoes received from the target. The radar robot pilot can "see" and follow the target at night, in fog, or above the clouds. This missile was used by the Navy to destroy many tons of Japanese shipping during the last year of the war.

Profile of a finished diamond die for drawing wire down to 0.0008 inch in diameter. The electrical method for drilling small diamond dies, developed by NBS during World War II, eliminated almost 100 man-hours from older processes, completely revolutionizing the fine-wire diamond die industry.

These are a few of the accomplishments of the National Bureau of Standards as it enters its second half-century.

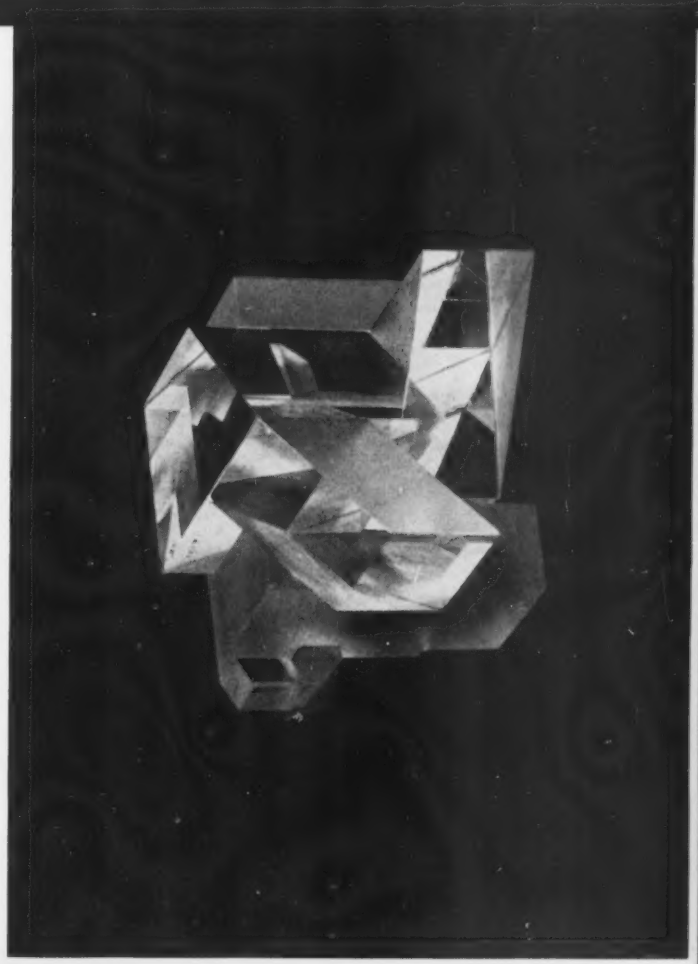


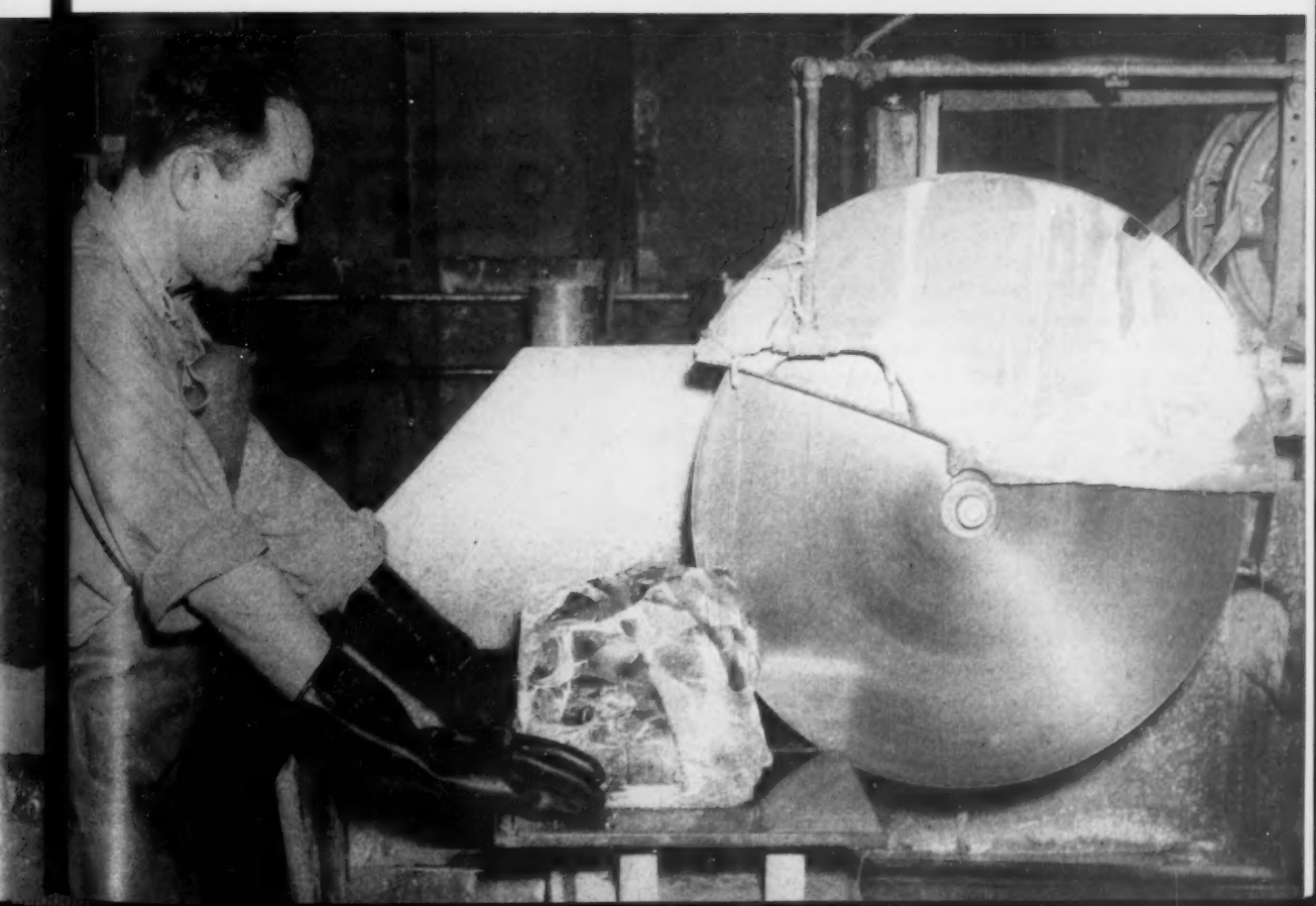
Upper left: A pot of molten glass is removed from one the melting furnaces in the bureau's Optical Glass nt. Temperatures in the neighborhood of 1,400° C required for fusion of the sand and other ingredients a homogeneous transparent material.

Lower left: Slow cooling of molten optical glass duces large chunks, which are removed by breaking n the melting pot. These chunks are then cut into aller pieces from which lenses and prisms are made.

Upper right: The optical range finder, used by the ed forces to measure the distance from an observer a target, is one of the most intricate and costly of opti- instruments. This coincidence prism—an important ment in range-finder accuracy—was constructed by enting together a number of smaller prisms made m optical glass produced at the National Bureau of ndards.

Lower right: Large pieces of optical glass produced in bureau's Optical Glass Plant are sawed with a dia- nd saw into sizes convenient for molding into blanks m which lenses, prisms, and flats can be made.





Present Program of the National Bureau of Standards

E. U. CONDON

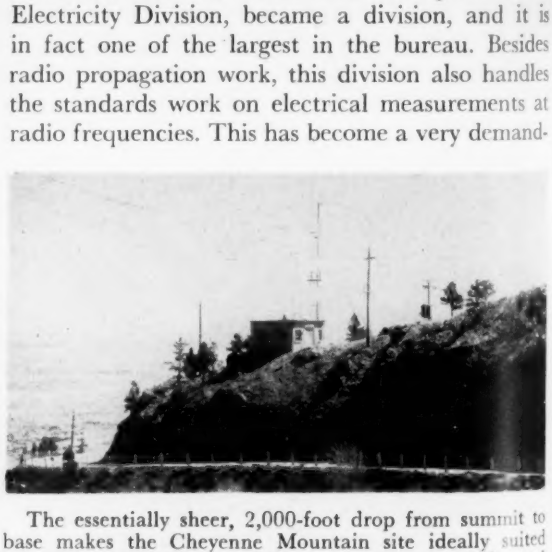
Dr. Condon, who was born at Alamagordo, New Mexico (or the heart of today's rocket-experiment country), took his Ph.D. in physics at the University of California in 1926, after which he studied for a year in Göttingen and Munich. Later he taught at Princeton, Minnesota, and Columbia, and was associate director of Westinghouse Research Laboratories from 1937 until 1945, when he became director of the National Bureau of Standards. On October 1 Dr. Condon will take up his new post as director of research at Corning Glass Works.

THE fields of activity of the National Bureau of Standards are physics, chemistry, mathematics, and engineering. One cannot, of course, sharply define the division between these disciplines and, as a matter of fact, as the fields of biophysics and biochemistry show, it is becoming increasingly difficult to distinguish between border regions even when the biological and physical sciences are juxaposed. Thus the National Bureau of Standards is also engaged in activities touching upon the biological and medical sciences. The work in X-rays and natural and artificial radioactivity reveals how inevitably necessary this is while there is considerable activity relating to instrumentation for the biological and medical sciences. For example, Newman, Swerdlow, and Borysko recently developed a new method for microsectioning of biological tissue, and Broida has developed a heart pump and an artificial heart valve. At the same time progress is being made in the important field of synthetic blood plasma.

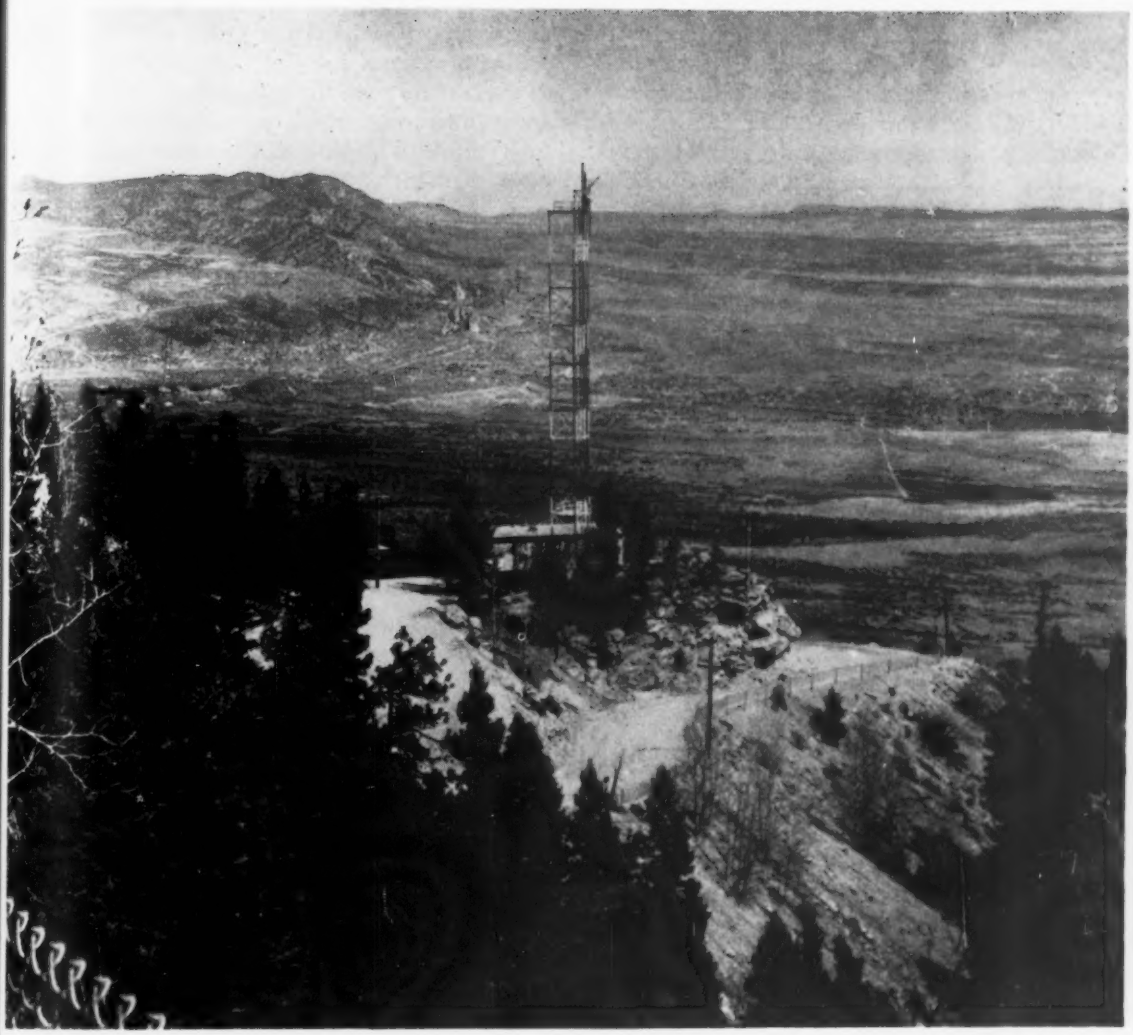
Within the physical sciences, the work of the bureau consists of both pure and applied research, development and engineering, testing, calibration, and specifications, and, finally, general scientific services—largely of an advisory kind.

A major aspect of NBS activity is concerned with national defense. A large number of important military problems are under study in nearly every section of the NBS laboratories, but the larger activities of military importance are (*a*) the research on factors affecting ionospheric and tropospheric radio propagation and the operation of a prediction service concerning ionspheric conditions, (*b*) the research and development responsibility in the field of proximity fuses for nonrotating projectiles, (*c*) work on chemical properties of atomic energy materials and on problems related to protection of personnel from their radiations, and (*d*) continued development of special guided missiles for the Navy following on the pioneer lines opened up by the work on the Bat.

Arrangements for carrying on the radio work were made by agreement and support of the Joint Chiefs of Staff, who decided that the military needs for research in radio propagation should be made the responsibility of a civilian organization at NBS, which would also take care of civilian interests in the same field. As a result of this decision the Radio Section, which had been part of the Electricity Division, became a division, and it is in fact one of the largest in the bureau. Besides radio propagation work, this division also handles the standards work on electrical measurements at radio frequencies. This has become a very demand-



The essentially sheer, 2,000-foot drop from summit to base makes the Cheyenne Mountain site ideally suited for simulating communication between aircraft and ground. Permanent installations on the Colorado and Kansas plains as far away as 300 miles will receive the transmitted signals.



For intensive investigation of radio propagation phenomena, NBS has recently installed powerful radio transmitters on the summit of Cheyenne Mountain, Colorado. (See figure on preceding page.)

ing task in view of the rapidity of progress in recent years in making use of an ever-widening range of frequencies, now extending up to some 100,000 megacycles/second.

The radio division, called the Central Radio Propagation Laboratory, has a staff of some 400 technical people. Besides the laboratories here, it operates a dozen ionospheric observing stations, some with NBS personnel, and some by contract. These are located in the Pacific islands, in Alaska, Greenland, and Canal Zone, as well as at several places in the continental United States. Data from these and other stations operated by other governments with which we cooperate pour into Washington for immediate use in the prediction service and analysis, as part of a research program to improve our fundamental understanding of ionospheric processes. This part of the work involves close cooperation with the solar astrophysicists at both the Mount Wilson Observatory and the High Altitude observatories at Boulder and Climax, Colorado. In addition, the radio division operates the well-known standard frequency transmitter WWV from Beltsville, Maryland, and a 400-acre field station for radio experiments at Sterling, Virginia, about thirty miles west of Washington. We are now building transmitters and receiving stations for an elaborate observing program to determine tropospheric factors affecting the propagation of radio waves at the range 100 Mc–1000 Mc, and perhaps higher. The transmitters will be located atop Cheyenne Mountain, just west of Colorado Springs, and the receivers on the plains several hundred miles to the east.

Architects are at work on plans for new modern radio laboratories to be built at Boulder. Present

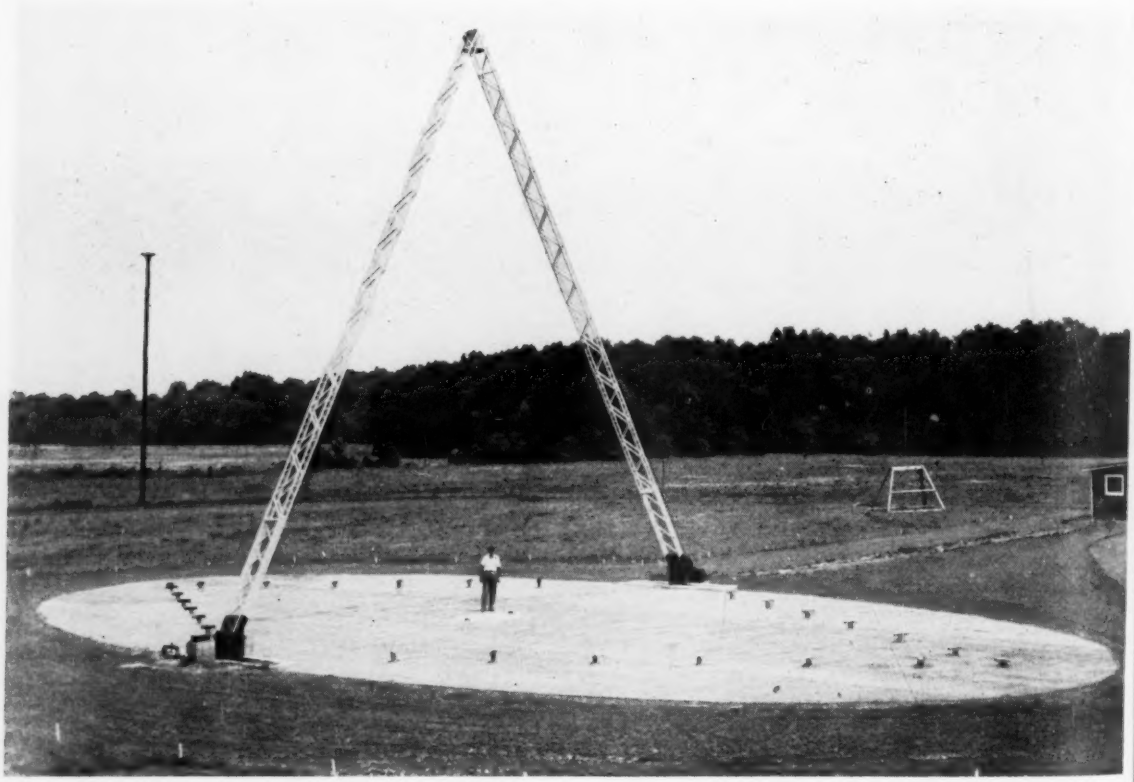
prospects are that construction will start in the spring of 1952 and that the laboratory will be ready for occupancy in the fall of 1953. The citizens of Boulder, which is the seat of the University of Colorado, presented the federal government with a splendid 220-acre tract for the NBS Boulder Laboratories.

The acquisition of a large site in this part of the country has already proved valuable for other than radio work. Construction of a special-purpose laboratory for certain work that NBS is doing for the Atomic Energy Commission is now going on. This building will be completed and occupied on a high-priority schedule before the construction of the radio laboratory even begins.

Within the past year there has been a great increase in all kinds of military work, some of it in wholly new lines of activity and some in the direction of stepping up the effort in fields in which we were already engaged. The electronic ordnance work, for example, must be greatly increased in order to take care of the peculiar requirements of fuses for guided missiles. Although a splendid new laboratory building for this work was provided on our grounds by the Army Ordnance Department just at the end of the war, these facilities are now so inadequate that the total laboratory space devoted to this work must be enlarged by a factor of four or five. The bulk of this expansion will take place elsewhere, at a site not yet determined, although some of it must take place in Washington because of the urgent time schedules we are trying to meet for the armed services.

The work we have been called upon to do for the Atomic Energy Commission has also tended to increase rather than decrease during the past several years, and it carries over into a number of distinct fields that cannot be publicly discussed. The work in radiation physics has been strengthened by construction of a laboratory building to house a 50-million-volt betatron and a 180-million-volt synchrotron.

Need for better facilities for the Navy guided missile work than the several crowded and unsatisfactory Quonset huts now used as laboratories here has been recognized this year by the Congress. For reasons of economy, both of money and of time, there has been assigned to NBS a large un-



To develop efficient antenna systems for ionosphere sounding equipment, NBS maintains a model antenna range at Sterling, Virginia. At the vertex of the 50-foot "A" frame is a target transmitter, and on the ground directly below the transmitter is the antenna under test.

used naval hospital at Corona, California, about forty miles east of Los Angeles. This has recently undergone the necessary remodeling and was activated last summer as the Corona Laboratories of the National Bureau of Standards. Here we have more than 100 acres and a large group of good buildings, which will take care of the guided missile work and other related development projects.

In the period under review several major organizational changes have occurred. One of the most important of these has been the development of the Applied Mathematics Division under the leadership of John H. Curtiss. This was started in a small way to continue the work of the Mathematical Tables Project formerly located in New York City and also for the purpose of introducing modern statistical techniques for design of experiments and analysis of laboratory data into all the NBS research and testing work.

Hardly had this been done when we were approached by Admiral H. G. Bowen, then chief of the newly established Office of Naval Research. He was keenly aware of the military needs for a central computing facility of a higher sort, which would be capable of rendering a consulting service on problem formulation, as well as being able to handle large blocks of mechanized computations. He suggested the appropriateness of meeting this need through an NBS-operated facility.

At the same time extensive interest was developing in automatic digital electronic computers. The Bureau of the Census, and soon thereafter several other government agencies, including the Office of the Air Comptroller and the Army Map Service, asked for NBS assistance in developing and procuring such computers. All these things have worked together to make the work in applied mathematics much more extensive than was envisaged when it first started. Besides the mathematical work on computers in the Applied Mathematics Division, there is a section in the Electronics Division under S. N. Alexander which has done a splendid job on development of new engineering designs and techniques in this field. This work has resulted in many specific contributions to the art and to construction of the SEAC (National Bureau of Standards Eastern Automatic Computer), which has been operating for many months on a twenty-four-hour-a-day, seven-day-week schedule on military mathematical problems and in testing new circuits and components to be used in future more elaborate computers.

The mathematics program has also involved

This 30-foot copper-tube absorption cell, containing ammonia gas at 10μ to 15μ pressure, is the heart of an improved atomic clock, which shows great promise as a new, atomic standard of frequency and time. The constant frequency for controlling the clock is derived from the absorption line of the gas when a 23,870.4-Mc signal is passed through the cell. The ammonia clock is one of four different atomic clocks now under development at the National Bureau of Standards.

the establishment of a western unit known as the NBS Institute for Numerical Analysis, located on the campus of the University of California at Los Angeles. This unit carries on fundamental research on methods of numerical solution of mathematical problems and renders a computing service to government agencies and government contractors in the Pacific Coast area.

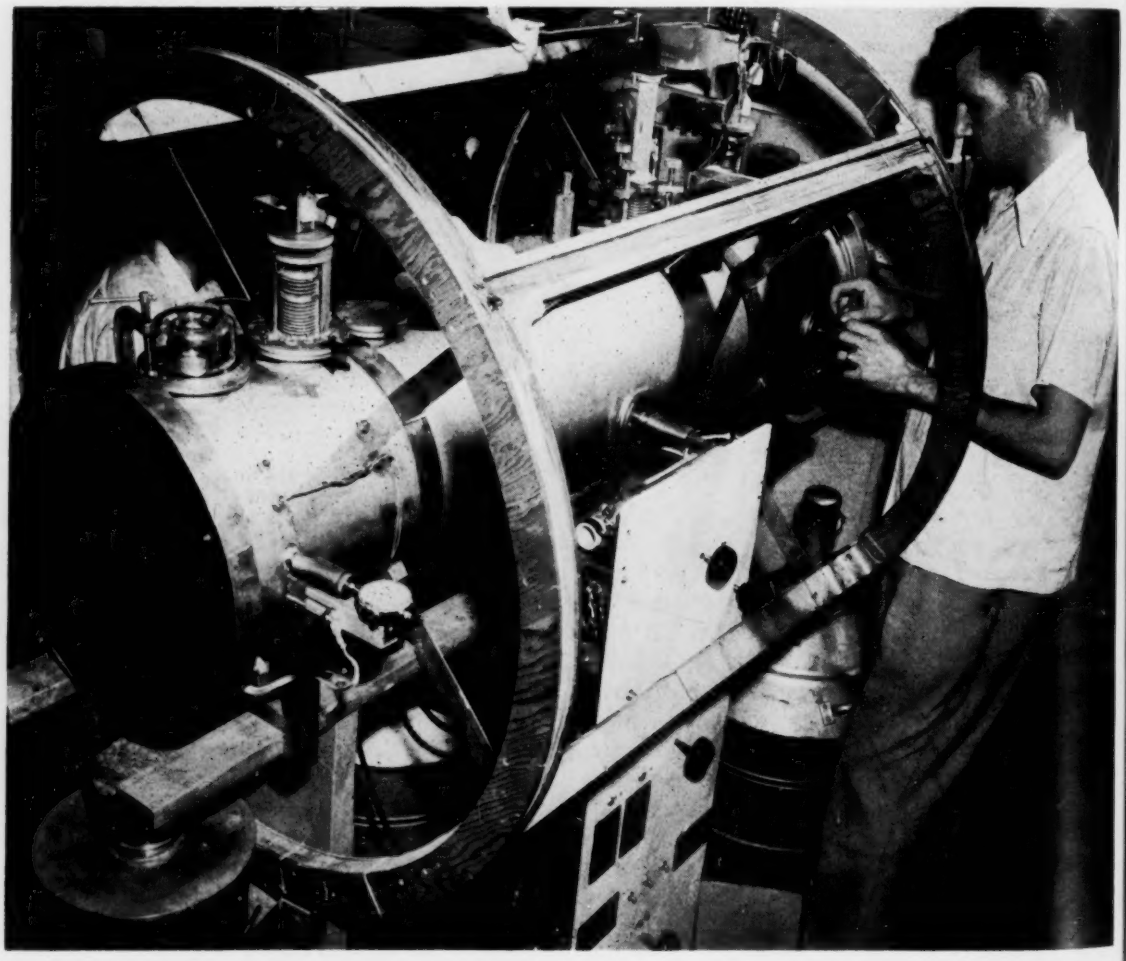
It would be impossible to mention all the specific things that have been and are now going on. Under present conditions, development problems, especially those for the military, tend to demand most of our attention, but it would be wrong to leave the impression that there has not also been a series of interesting advances in basic science, particularly in matters affecting precise measurement and determination of basic physical constants. In the postwar period, we have been able greatly to improve our spectroscopic facilities. William F.

Meggers turns out a steady stream of analyzed spectra and has done a great deal to perfect the use of Hg^{198}, artificially made from gold in the nuclear reactors, as an ultimate standard for precise measurement of length by interferometry. Standard lamps have been supplied to the International Bureau of Weights and Measures near Paris and the National Physical Laboratory in London and are now available for general scientific use.

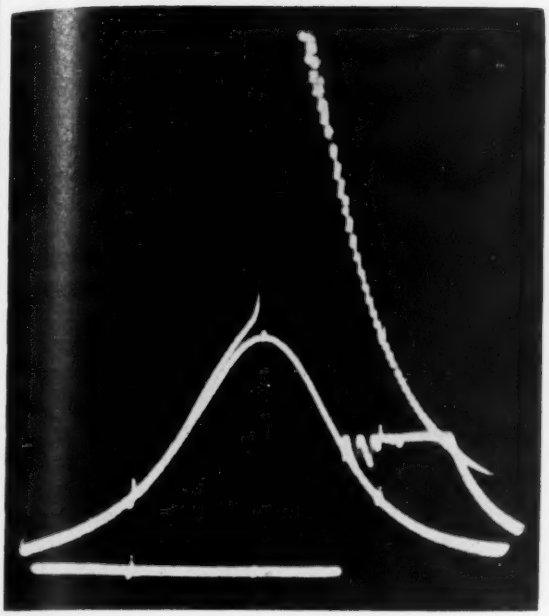
The attainable precision is such that the old platinum meter bars that have served as material standards for preservation of the meter are now scientifically obsolete. As soon as the new technique can be made more widely known and more generally available, it will be proper to propose an international legal agreement for use of the better method.

An interesting achievement was what is popularly known as the "atomic clock," in which the resonant absorption of microwaves in ammonia gas provides the frequency control element of a time-measuring device that can be made precise and completely independent of any vagaries in the period of the earth's axial rotation. Other atomic time-keeping possibilities involving control by resonant frequencies arising from the hyperfine structure of the atoms in a molecular beam of cesium atoms are also under active study.

In the field of fundamental atomic constants, a most useful contribution was the work of H. A. Thomas, R. L. Driscoll, and J. A. Hipple, in determining the gyromagnetic ratio of the proton in absolute units. This makes possible the use of proton magnetic resonance methods for the convenient determination of magnetic fields in many other related experiments, and in combination with

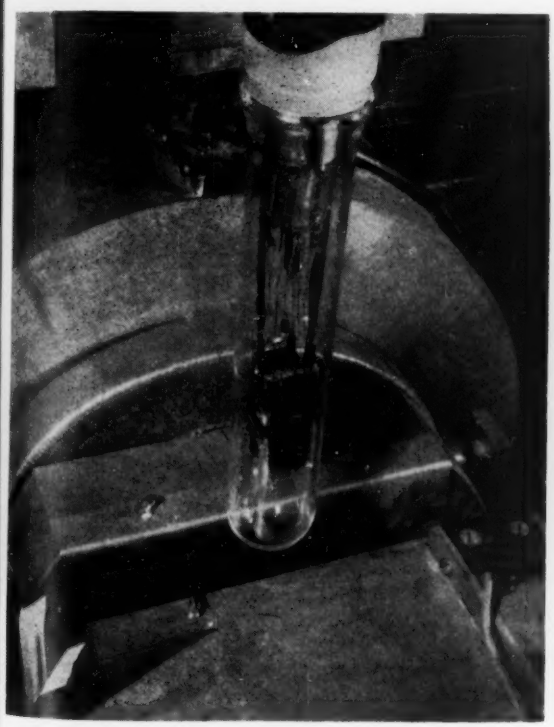


The NBS new Atomic Beam Frequency and Time Standard, in which a sharp spectroscopic line in the frequency spectrum of cesium is used to stabilize a quartz oscillator. The device forms an integral part of a servo system that will supply correction signals to a frequency and time generator that has the highest potential accuracy of any type atomic clock, perhaps as high as one part in 10,000,000,000.



Oscillogram of engine "knock" (jagged portion of curve, upper right) obtained by NBS in studies of pressure changes within a specially constructed high-compression engine. The sinusoidal curve shows pressure changes during a normal nonburning cycle. The second curve, in which knock occurs, follows the first curve through most of the first half of the cycle; it then rises sharply as the compressed gas ignites.

A recent NBS development in the field of atomic instrumentation is the omegatron (within the glass tube), which makes use of the cyclotron resonance frequency of ions to discriminate between particles of different masses. Although the omegatron operates on the same fundamental principle as a large cyclotron, the heart of the instrument is little larger than a package of cigarettes.



So-called Grasshopper in upright position, ready for operation. This air-launched automatic weather station, developed by NBS for the Navy Bureau of Ships, will automatically set itself up and transmit weather data by radio. After the station has parachuted to earth, explosive charges are used to disengage the parachute, raise the station to an upright operating position, and erect a telescoping antenna to a height of some 200 feet.

work in other laboratories it is improving knowledge of several basic atomic constants. Another contribution of importance is the development of the "omegatron" by Hipple and his colleagues. This is a miniature precision-built cyclotron, the object of which is to determine accurately the resonance frequency of positive ions circulating in a uniform magnetic field. With it a totally new determination of the faraday has been made, which seems to have cleared up the puzzle of the long-standing discrepancy between the values obtained electrochemically from the silver and the iodine voltameters. The present position strongly favors the iodine value.

Another field in which we have been able recently to strengthen our basic work is in fundamental research in cryogenics. Under construction is a small addition to our low-temperature laboratory where there will soon be installed a large helium liquefier built for us by Arthur D. Little, Inc. Besides problems of fundamental thermometry and thermodynamics, here the principal fields of interest are research on the puzzling phenomena of superconductivity, and the equally puzzling problems posed by the superfluid form of liquid helium called Helium II, the state assumed by liquid helium below 2.6 degrees.

These few examples of the present program of the National Bureau of Standards can only suggest the nature and scope of the work. They are typical of the work of the fifteen divisions of the bureau: Electricity, Optics and Metrology, Heat and Power, Atomic and Radiation Physics, Chemistry, Mechanics, Organic and Fibrous Materials, Metallurgy, Mineral Products, Building Technology, Applied Mathematics, Electronics, Ordnance Development, Radio Propagation, and Missile Development. The growth that I have implied has come about because, in the more familiar fields, science has demanded greater precision in measurement, better standards of measurement, more sensitive instruments, and more precise values of the properties of various materials and of physical constants. In newer fields, such as atomic and nuclear physics, low- and high-temperature physics, radio propagation at the higher frequencies, and high polymer research, science and industry have made new demands on the bureau. Meanwhile, the present emergency has confronted us with many pressing problems of the military services.

SMO ON THE AIR

Station	Sponsor	Time
	Sunday	
KLBM, La Grande, Ore.	Baker-Union Department of Health (Research Report)	10:15 A.M.
	Monday	
WOI-FM, Ames, Iowa	Iowa State College of Agriculture and Mechanic Arts (Articles of Interest)	7:45 P.M.
	Tuesday	
WEVD, New York City	Wendell W. Rázim (Science for the People)	9:00 P.M.
	Wednesday	
CKPC, Brantford, Ont.	The Telephone City Broadcast Limited (Modern Science)	9:45 P.M.
	(Irregular)	
KBKR, Baker, Ore.	Baker-Union Department of Health (Research Report)	....

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Soul and Mask of Bolshevism

SERGEY LEVITZKY

The author, who was born in Russia in 1909, fled with his parents to Estonia after the 1917 revolution. He received his Ph.D. from Charles University in 1938, where he was at the same time engaged as a lecturer in the Russian Free University. Because of MVD persecution he was forced to leave Prague in 1945. Subsequently he spent four years in German DP camps and eventually arrived in the United States in 1949. He is at present an instructor in Russian language and literature in the School of Foreign Service at Georgetown University.

BOLSHEVISM is the result of an attempt to carry out Marxist ideas in Russia. There is no doubt, however, that the Russian revolution set out on the path of Lenin, not of Marx, and that Stalin's tyranny makes even Communist old-timers secretly sigh and recall the "golden days" of their former leader.

The discrepancies between the prophecies of the *Communist Manifesto* and the actualities of Stalin's oligarchic and slave state have attained such dimensions that many Western Marxists hold that Stalin has "betrayed" Marxism. Under the mask of Marxism, they say, the silent restoration of former autocracy and Russian imperialism is taking place in the Russia of today.

The opinion that Stalinism is only a perverted Marxism is very popular. This statement contains some fraction of truth, but the ensuing conclusion—that the robes of Marxism remain unstained, and that the only factors at fault are Stalin himself and the "Russian soul"—is a fallacy. The true facts are ignored in favor of a theory based on error. This error is based on the assumption that the ideals of Marxism could be realized without the violation of democratic freedom (except for a short period during the revolution), and that Marxism does not contradict the principles of humanitarian ethics.

The followers of this theory forget that the thesis of class struggle and of the inevitable dictatorship of the proletariat was introduced by Marx. The thesis that Marxism is a theory of the transformation of the world in terms of violence was set forth by Marx and also by Engels. It was Marx who taught that man is a completely social being, historically predestined to the "collectivization of souls." It was he who preached the pre-eminence of the collective over the individual, justifying in advance the violation of individual freedom. Militant atheism and dialectical (i.e., dynamical) materialism constitute the soul of Marxism.

The elements of democracy in Marx lay in his conviction that the dictatorship of the proletariat will be the dictatorship of a majority over a minority. He did not foresee the degeneration of the dictatorship of the proletariat into the dictatorship over the proletariat. He was against direct violation of religion and free thinking, not as a democrat, but as a materialist and an evolutionist; he believed that religion and idealistic philosophy would die out by themselves after the foundation of a collectivistic economic basis for society.

Marx wished to believe that true democracy and true humaneness would triumph at the end of history under the reign of an established communism. But he is also known to have stated that Communism is not an ideal according to which the reality should be reformed, but a condition that logically and inevitably will appear in the process of a class struggle marked by revolutions.

In other words, the materialistic conception of Marx lowers and nullifies the elements of humanism included in his theory. Above all, Marx needlessly sacrificed personality and freedom on the altar of his social Utopia right at the beginning. Not only the actual in the present, but the eternal in the present and the future is thus sacrificed. Spiritual values are destroyed in return for the promise of Utopian welfare.

The regime of Stalin is the logical conclusion of the socialism of Marx. Marx brought forth Lenin, who in turn brought forth Stalin. In Stalinism Communism reaps the practical fruits of the theoretical seeds of evil sown a hundred years ago by the *Communist Manifesto*. If, at the present time, we find Marxists dismally denying the monster born out of the depths of Communism, it only proves that they did not know what they were

doing, that they did not possess sufficient consistency to draw all conclusions from the basic idea of Marxism: equality in slavery. They accepted Marxism with their minds but were not completely infused with its spirit.

The Russian East reflects the true aspect of Marxism socialism, whereas to the West it is still dimmed by a screen of flattering fallacies. Thus the wrath of Western half-Marxists is the wrath of Caliban, who refused to recognize his true reflection in the mirror. If Marxism were struggling with capitalism only, it might have possessed relative truth. But Marx began from the start a fierce struggle with the very foundations of Christian culture. To his followers, Marxism was a new religion, and, as such, it claimed the "whole man." In the totalitarian character of this doctrine lies the seed of the totalitarian regime established by the October revolution in Russia.

Marx himself had some fragments of instinctive humanism left. But his theories call for an immense crisis and for destruction of every feature of humanism. Leninism, with its antihumanitarian hatred, and complete lack of tolerance, expressed this call more openly and became, therefore, the further logical step in the development of Marxism.

The doctrine of Marx was inspired by the revolutionary and messianic spirit. But in Lenin only a little of this messianism was left. He accepted Marxism as a religion in which he had a blind, dogmatical belief. He was preoccupied not so much with the final aim, as with the practical means of its realization.

Frantically intolerant as concerns the materialistic foundation of Marxism, he appeared sneakingly elusive and realistic, even cynical, in his tactics. His trend was more toward the destruction of the past than toward the creation of the new world. A demigod of revolution, he was the genius of destruction, the instigator of hatred and revenge. His outstanding demagogical ability played the part of a powerful detonator, which produced the explosion of the forces of social resentment smoldering in the subconsciousness of the people.

As no one before him, he could reach down and bring to the surface the lowest instincts of the masses and use them as revolutionary dynamite. The main difference between the February (democratic) and October (Communist) revolutions lies in the fact that the first was a people's revolution —though the people failed to play the leading part. The latter was a revolution of the proletariat masses, although these masses were in relative minority to the people itself. *The power of the Bolsheviks came from their ability to establish contact with the people's subconscious.* They awakened the complex of social inferiority and called for its supercompensation. "The last shall be first;" under conditions of political illiteracy such appeals proved to have a tremendous effect.

"They are slaves, though rebels"—these are the words of Dostoevski on the psychology of the unenlightened masses. Lenin succeeded in offering an escape valve for the rebellious elements and simultaneously became the leader they were subconsciously seeking. This is a classical example of Freudian psychoanalysis applied to social life. As a result of Lenin's demagogy and his understanding of the psychology of the masses, the Bolsheviks succeeded in rising to power on the crest of the revolutionary wave and have tenaciously clung to their power ever since.

Regardless of the cynical realism and Machiavellian politics of Lenin and his followers, and in spite of their concentrated efforts to seize and retain power, they did sincerely believe in a Marxist Utopia built from a scientific blueprint. They plunged the nation into the inferno of a civil war in the strong belief that it was the indispensable though bloody purgatory that lay on the road to the Communist paradise. For this point of view Lenin and his old guard could be called "the idealists of evil."

The case of Stalin appears to be completely different. It might be expected that after the Bolsheviks had seized and strengthened their power, they would begin to implement Communism through socialism, and in the process the terror would be gradually eliminated. However, it is only too well known that Stalin's terror has increased in proportion with the "building of Socialism in one country." The mass collectivization and industrialization were a direct totalitarian offensive of the party against the people. The Bolsheviks themselves term the collectivization "a revolution from above," whereas the October revolution was an explosion from "underneath." The collectivization was in fact a *revolution of the party against the masses.* The terror itself attained unheard-of dimensions. Bolsheviks have always been totalitarian, but only from the time Stalin actually began to rule did the USSR become a totalitarian state in the full meaning of this word: a state built and maintained by total compulsion and total terror.

The cadres of the party, however, were still inspired by the idea of building socialism in one country by any and all means. When in the twenties hundreds of thousands of armed party members forcibly compelled farmers to enter *kolkhozi* and liquidated kulaks, this attack from above

might have collapsed had it not been for the enthusiasm of the party cadres. But it became well known that the party itself was headed for a general "clean-up," which happened soon afterward. It was thoroughly purged and descended to the position of a robot directed by the Politburo.

The "idealists of evil" resigned and the "realists of evil" took their place. The generation of Stalin-bred party members not only lacked whatever principles and scruples the former party members still possessed, but they had already lost faith in the final aim. At present party members are not required to have the conscience of a convinced Communist; they are expected to possess the conscience of an executor of the general line of the Politburo.

Power is not a medium any more, it is the final aim itself: not the power of the class or of a party, but the power of the Politburo—more exactly of Stalin's autocracy and of the directing apparatus of the NKVD–MDV.

The pre-eminence of politics over economics introduced by Lenin led in the first place toward pre-eminence of the party over the class, over the proletarian masses, and finally to the pre-eminence of Stalin over the Politburo. Long ago the party became a mere apparatus and no longer a living organism. The anonymous apparatus of party compulsion has engulfed the party itself.

The development of Bolshevism in Russia resulted in a reversal of aims. If, before, the Bolsheviks had endeavored to seize power to build socialism, now socialism became an expedient to maintain their power. This transformation may be called "the heterogeneity of ideas." To Lenin power was primarily the means for the realization of his ideas. To Stalin totalitarian power is a final aim. Lenin depended upon the revolutionary enthusiasm of the party cadres and the resentment of the masses. Stalin uses iron party discipline and a system of mutual spying and fear for the masses. The nation lives under an immense strain and in an atmosphere of dread of the totalitarian, and therefore all-present, government. At the present time the Bolsheviks lead and direct the nation's subconsciousness not with appeals to enthusiasms (those deteriorated long ago into conditioned party slogans), but by means of fear, a system of spying and denunciation crowned by totalitarian terror.

This fear is of a peculiar nature. It is not fear of danger from above; it is a totalitarian fear as the party and party agents infiltrate the nation from inside. The party is an omnipotent and all-present anonyme, with no clear-cut frontiers to reveal the enemy. The party demands from its members and victims not only loyalty, but active, though slavish, cooperation in party politics. No part of cultural or everyday life is left neutral. From family life to religion, everything is mobilized for the strengthening and dissemination of power. Purposeful lies occupy the throne of truth and must have a mask of truth. The five-year plans are substituted for eternity.

Yet those who have power are also ridden by fear, not the fear of unwitting deviations from the general line as experienced by average party members, but the fear that drives upper-layer members of the Communist apparatus. This fear is obviously the reverse side of the power mania. The Bolsheviks aspire to the seizure and capture of the "whole man" and the whole world. Yet he who grasps at everything loses everything, too. The craving for power is insatiable and is always followed by a persecution complex. Among Bolsheviks who are dimly aware of the usurping character of their power the persecution complex has reached unheard-of dimensions. As a direct result of this mania there arise the myths about enemies of the people, sabotages, spies, etc., etc. It seems to be a vicious circle: the power mania stimulates the complex of persecution, which in turn increases the power mania. This *perpetuum mobile* of fear drives the whole apparatus of the Bolshevik system.

People possessed by the spirit of Bolshevism live in a fantastic world permeated with fictions similar to those that torture the insane. As the result of their mania, distorted ideas are projected into reality. In the selection of means of realization of their aims, however, these lunatics display a very evil, realistic cynicism.

It is well known that madmen sometimes reveal extraordinary resourcefulness, ingenuity, and even realism in the selection of means of attainment of their insane ideas. Bolshevism is a disastrous disease of the subconscious, not of the conscious, mind. The Bolshevik consciousness, as such, remains sober. This is the reason why rational argument fails to convince people possessed by the spirit of Bolshevism. The final aims of the Bolsheviks, however, are of a Utopian character, and the motivation of their actions derives from psychosis. The situation calls forth the words of Berdyaev: "Utopia can be achieved. Maybe soon the time will come when people will give anything to get rid of a realized Utopia." This is obviously a paradox and, as such, should not be taken literally. Yet it must be admitted that, in the name of Utopia, uninvited saviors of humanity created a regime that compels and distorts the spirit of individuals to an unimaginable degree. In the light

of this fact Bolshevism stands out as a tragic caricature of a realized Utopia.

We are now approaching the main problem: Could the scientific socialism of Marx be termed a Utopia? We shall abstain from criticizing Marxism as a social and economic doctrine. As such, Marxism has already endured heavy blows from contemporary science and from reality, too. The struggle of the classes in the West is not increasing; quite the contrary, socialism infiltrates capitalism and the proletariat becomes increasingly bourgeois.

Modern socialist parties, including reformed Marxists, meet with a good response from the workers. The necessity of a complete revision of the materialistic basis of the social philosophy becomes more evident to democratic Marxists. The organical pluralism of the factors of social existence is replacing the one-sided conception of materialism. The dialectical materialism from the epistemological point of view is but a variety of naïve realism. From the scientific point of view its endeavoring to explain everything is not scientific. True science is increasingly conscious of its limitations. The development of modern physics leads to the acknowledgment of the nonmaterialistic basis of matter. Moreover, dialectical materialism in itself is contradiction in terms, as dialectics (i.e., creative evolution) and materialism are incompatible. A criticism of materialism does not fall within the scope of this article, however.

It is important here to emphasize that the success of Marxism may be explained primarily by the fact that, quite inadvertently, it became in the eyes of its followers a new (secularized) religion. It is a religion denying eternal life and the existence of another world, and offering the realization of its ideals within the limits of life on earth. Marxism is a religion based on materialism, it believes dogmatically in the realization of good primarily through creation of a new social and economic order founded on the socialization of the means of production and of production itself. As, according to Marx, man is a social being, the collectivization of the individual should follow immediately after the collectivization of economic factors. The individual is only a "reflex of social relationships." This thesis proves the Utopian character of the whole theory. For man is a free being, though occasionally inclined to become a slave. He is primarily a religious being. In following the theory of "world transmutation" Marxism strives to exterminate freedom and create a man with a "materialistic and socialistic" soul. As a theory of compulsory transformation of the world, Marxism is primarily a theory of the compulsory transformation of the individual. Inasmuch as human freedom instinctively opposes the basic theory of Marxism, realization is possible only by way of compulsion. Dostoevski, better than anyone else, foresaw the inevitable deterioration of socialism into dictatorship, into the demand for "thousands of heads" for the greater triumph of this disastrous fallacy. "There is no Marx but Lenin and Stalin is his prophet."

There is only one step from Utopia to dictatorship. Paradoxical as it may seem, any attempt toward the realization of a Utopia does not bring it closer, because the Utopia is violently opposed by human freedom, which is instinctively opposed to the Procrustean bed of Marxist schemes; therefore, while Marxism is achieving radical socialism, it tends to divide humanity into two classes: those in power, and the masses (the objects of an immense socialist experiment).

The Communist experiment in the countries of eastern Europe demonstrates that the methods are similar, be it among the satellites or in Tito's Yugoslavia, and are not inherent in Russian Communists only—just as the symptoms of cholera or insanity do not vary with races or nations.

Arthur Koestler raises the question of Communist ethics in his recent books. The Rubashevs, the Communist disciples of Lenin, are being replaced by the Ivanovs, the Communists trained by Stalin, faithfully devoted to their leader. Koestler himself sees the evil in the acceptance of the idea of "the end justifies the means." It is, however, necessary to add that the very nature of the Communist ideal, in view of its sanctioned immorality, inherently requires that any expedient be permissible. A Communism where the means would not be justified by the end would cease to be Communism.

The theory of Marxism is extremely rationalistic. This theory does not recognize the irrational in the natural world, in history, or, particularly, in human nature. A man, to Marx, is a socioeconomic being. Except for his social relationship based on economic factors he does not exist. The historical process was irrational until we learned from Marx the laws of social development. As soon as a man accepts these laws he is able to accelerate the historical process, which invariably shows a trend toward Communism. The main psychic factor for the speeding up of historical process, and the ultimate realization of Communism, according to Marx, is the material interest based on the international solidarity of the worker class, plus hatred of the "class-enemies."

The success of Marxism was due, however, to a

quite different, purely irrational factor: a religious belief in the atheistic and rational ideal of a classless society. The main driving force of Communism proved to be social resentment based on envy and the desire for revenge—a complex of social inferiority plus a yearning for overcompensation of this complex. This is clearly an irrational force. "The first shall be last, and the last first." But as soon as Communism attains power, terror becomes its main psychological device. Communist propaganda has no success behind the Iron Curtain (paradoxical as it may seem), for people know its "benefits" from bitter experience. Communist propaganda in Russia does not even expect a response. It is directed in such a way as to keep people constantly and systematically misinformed. "A lie repeated a thousand times sounds more trustworthy." Communist propaganda in Russia influences consciousness by means of an advertisement-like campaign and the subconsciousness by fear. Through unexpressed, but "well-meant" threats propaganda instills in the defenseless victims a series of fictions, which either declare the existence of nonexistent conditions (i.e., "socialism in Russia has been achieved"), or the nonexistence of existent conditions (i.e., "there is no exploitation of workers in the USSR"). No one believes these fictions, but officially and publicly everyone pretends to believe them. The very borders between truth and falsehood are being erased (in the manner recently depicted by George Orwell in *1984*). "True" is everything that serves the line of the Politburo, whereas real truth is suppressed with cruelty.

The exercise of terror brings its punishment to the oppressors, as well. It implants in their souls a secret fear, which is openly projected into reality in the form of strengthening of a terror. Their persecution complex forces them to search for new and more effective means of enlarging their power. This picture has little in common with the primary psychological thesis—the general overall material interest.

In their aim of rationalizing a human soul the Bolsheviks secured an opposite result: they became themselves the victims of irrational forces, of power mania and of a persecution complex. Irrational forces took possession of Bolshevism from inside. They started riding the tiger and could not get off. Long ago the power of Bolshevism in conquered countries ceased to rely upon enthusiasm and is now founded on a hypnosis of fear and omnipotence of the MVD. To the observer this factor seems only to increase the power of Bolshevism, but actually it undermines it from within.

The tragedy of the struggle with Bolshevism is in the fact that up until now only those who experienced it personally were ready and willing to fight it. But for those who experienced it, it was mostly too late to start fighting. At present Bolsheviks strive to conceal their ideological bankruptcy and endeavor to perform the role of a victorious army of world revolution. The truth is that only the mass-produced hypnosis of fear prevents a revolution against the Red government.

One may think that the practice of Bolshevism created a regime contradictory to the principles of Marxism. Instead of socialism the Communists achieved the *shigalevshchina* of Dostoevski, the "hierarchical collectivism" of Orwell—that is, the perfect system of collective slavery. But, actually speaking, the deterioration of classical Marxism into Stalin's despotism occurred as a result of the imminent trend toward despotism contained in the very nature of the Communist ideal, as of an absolutely unrealizable Utopia. The idea of Marxist socialism in itself is therefore to be held responsible for the whole tragic experiment of Bolshevik dictatorship. The failure of Communism and its inevitable transformation into "Bolshevism" constitutes the imminent nemesis of the Communist Utopia. A compulsory realization of a Utopia conceived as a subjective good inevitably leads to the creation of an objective Utopia of evil.

At the present time, at least, the satanic falsehood of Communism has been exposed to those whose eyes are open. Contemporary Communism no longer possesses its former revolutionary enthusiasm. It rules uniquely by mass terror and fear. But fear is a double-edged weapon and can be turned against the oppressors. The proof lies in the ever-increasing fear of the cadres of the Communist state. The ideological and social bankruptcy of Communism is being exposed to the whole world. A basis for a new revolution, a revolution of the spirit, is slowly being built up. Fear paralyzes hatred but contains in itself a potential hatred of slavery and a love of freedom.

The next practical problem of the struggle with Communism lies in the overcoming of the hypnosis of fear, in the sublimation of fear into hatred for oppressors and an active striving for liberation. The conquered masses have already been driven by Communism to a state where they have nothing to lose, but where freedom, the most precious of all possessions can be gained.

Heredity and Handedness

D. C. RIFE

Dr. Rife took his Ph.D. at Ohio State in 1933. He had previously been an instructor in the Giffen School of Agriculture in Khartoum, Anglo-Egyptian Sudan, for three years. He has been professor of genetics at his alma mater since 1946 and is consulting geneticist at the Ohio State Experiment Station. Currently, he is on leave at The Faculty of Sciences, Fouad I University, Cairo, Egypt, as a Fulbright lecturer.

THERE are between 10 and 15 million left-handed people in the United States. Yet in spite of this, left-handers are a sadly neglected lot. Most standard equipment is made for right-handers. Members of the military forces are trained to shoot from the right shoulder, and to aim with the right eye. The chairs in most schoolrooms and colleges are made for right-handers, although there have been some notable exceptions in recent years. Zippers on clothing, the arrangement of violin strings, and the design of grass sickles and many other tools afford familiar examples of conventional conformity to right-handed standards.

Uniformity of standards makes for greater convenience and economy, but insofar as such uniformity may frustrate and confuse the minority of nonconformists, the ultimate damage may far outstrip the advantage. It is here that a knowledge of the part heredity plays in the determination of handedness is of practical value. If heredity plays no part, it would seem reasonable to assume that everyone could easily be trained to conform to uniform standards of handedness. But if handedness is wholly or partially inherited, it is probably unwise and certainly undemocratic to impose right-handed standards on everyone. The bulk of evidence indicates that handedness is a product of both heredity and environment, rather than being due entirely to one or the other.

All too frequently handedness has been attributed solely to environment or solely to heredity. Data of various sorts have been used in attempts to establish one fact or the other. For example, there is a positive correlation between the handedness of parents and children. When both parents are left-handed, about half their children are left-handed; when only one parent is left-handed, about one child in six is left-handed; and when both parents are right-handed, only one child in sixteen is left-handed. Although such findings are in accord with what might be expected if handedness is hereditary, they do not necessarily prove it. They could likewise be cited as evidence for the effects of environment. If a child's handedness is the result of imitation, correlations should be expected between the handedness of parents and their children.

Studies have been made to determine whether forced changes in handedness may result in stammering or emotional disturbances. Here, too, the evidence is conflicting. Some investigators have reported that left-handers occur no more frequently among people who stammer than they do in the general population. Yet there are plenty of cases where stammering is attributed to a forced change in handedness, although in many and perhaps most instances forced changes produce no apparent ill effects. Left-handers are frequently adept at "mirror-writing;" that is to say, they can write simultaneously with both hands, but in opposite directions. The script of the left hand, when seen in a mirror, appears to be identical with what was written with the right hand. Left-handers who have been trained to write with their right hands are especially gifted in this respect. An occasional right-hander may mirror-write, but he is less likely to be skilled at it.

There are two other types of observations in respect to handedness that shed light on its causes. Regarding these I shall propose a hypothesis that appears to be in excellent accord with the observations. The first observation concerns the incidence of right- and left-handedness in identical twins; the second deals with correlations of palm patterns with handedness.

Nearly 20 per cent of identical twins show intra-pair differences in handedness, often spoken of as "mirror-imaging." Identical twins result from the splitting of a single embryo; consequently the members of a pair possess the same genes. Twinning is

type of asexual reproduction, as much so as grafts or cuttings in plants. Any differences between the members of a pair must therefore be due to nongenetic factors.

One might assume from this evidence alone that handedness is entirely environmental. On the basis of pure chance, one might expect to get the observed distributions of handedness among identical twins. The pooled data of several investigators show about 78 per cent of pairs to consist of two right-handers, 20 per cent to be "mirror-images" of each other, and 2 per cent to consist of two left-handers, an almost perfect random distribution in which approximately 12 per cent of the individuals are left-handed. These ratios are what might be predicted as the result of chance alone, but other explanations have been proposed.

Newman postulated an asymmetry mechanism as the agency responsible for mirror-imaging in handedness, as well as in other traits, such as the direction of the spiraling of head hair whorls, profile resemblances, dentition, and various other bilateral traits. According to Newman's hypothesis, the extent of mirror-imaging depends upon the time in fetal development at which twinning occurred. When it occurs relatively early there will be no mirror-imaging; when it occurs during later stages mirror-imaging will be evident. During their separation the right side of one member is adjacent to the left side of the other member. If some degree of cell specialization has taken place in respect to bilateral traits at the time twinning occurs, mirror-imaging will be evident, whereas if it occurs at an early stage no mirror-imaging will result.

Although Newman's explanation may appear to be the logical solution, further analysis of the situation reveals certain weaknesses. If the degree of mirror-imaging in a pair of identical twins depends solely upon how early the embryo divided, we should expect to find a high degree of correlation between the extent of mirror-imaging in various traits within identical twins. There is a precise and orderly sequence of developmental changes during fetal growth. Yet extensive observations of twins have revealed no correlation between different traits in respect to mirror-imaging. For example, some pairs differ in handedness but are alike with respect to the direction of head hair whorl; other pairs show differences in handedness but are unlike with respect to hair whorls. Some other factor must be taken into account to explain why some pairs differ in handedness and others do not.

Lauterbach proposed that all left-handers are the result of the operation of an asymmetry mechanism. According to his explanation left-handers among the single-born are the left-handed survivors of identical twin pairs, the other member of which perished very early. This hypothesis does not account for most pairs of identical twins being alike in handedness. Furthermore, it is built upon the assumption that twinning is much more frequent, and that embryonic mortality is much higher, than they are generally believed to be.

Each of the explanations of intrapair variations in handedness in identical twins that I have discussed so far offers completely nongenetic solutions. Certain correlations between handedness and the configuration of ridges of the palms of hands suggest a hypothesis that explains the inheritance of handedness and provides a genetic basis for the fact that, although most identical twins are alike in handedness, some of them show intrapair differences.

The ridges on the palms correspond with those on the finger tips, which are so useful as identification criteria. They are established during the first four months of fetal development and do not change thereafter. Thus any correlations between palm ridge patterns and handedness establish irrefutable proof that handedness has an anatomical basis. The relations between handedness and palm patterns are of a subtle nature, and are apparent only when the prints of large groups of right- and left-handers are compared. Patterns occur with different frequencies among right-handers and left-handers. Moreover, left-handers show more similarities between right and left palms than do right-handers. This holds true for all pattern areas on the palms and, to a less marked extent, on the finger tips.

One pattern area is located near the base of the thumb. This is technically known as the thenar/first interdigital area (which we shall henceforth refer to as T/I). A pattern may be a loop or a whorl (Figs. 1, 2) or a combination of the two, whereas a patternless configuration is characterized by ridges that go from one side of the area to the other, like arches on finger tips (Fig. 3). Five different investigators have published results of comparisons in the incidence of patterns in the T/I areas of a total of 3,721 right-handers and 1,536 left-handers. The average frequency of T/I patterns among right-handers was 10 per cent, whereas among left-handers it was approximately 14 per cent. Although these differences are not of great magnitude, they are highly significant when treated statistically. Part of the increase of pattern frequencies in the T/I area of left-handers is due to

Fig. 1. Print of a right hand, showing whorl in the T/I area.

an increase of patterns on right palms. Among right-handers patterns occur much more frequently on left than on right palms (Fig. 4). Approximately 1 per cent of right-handers showed a T/I pattern on right palms only, whereas almost 3.5 per cent of left-handers showed these patterns on right hands only. Similar differences are encountered with respect to other pattern areas on the palms, and even on some of the finger tips. The associations between hand patterns and handedness prove beyond question that the latter cannot be due solely to postnatal environmental circumstances.

How may the observations on handedness in twins be reconciled with those on the associations of handedness with hand patterns? The first type of observation establishes the fact that environment is important, the second type demonstrates an anatomical basis for handedness. The following hypothesis appears to account satisfactorily for both types of observation.

A single pair of genes lacking dominance provides the genetic basis for handedness. Using *R* to symbolize the gene for right-handedness, and *r* to symbolize its alternate for left-handedness, people may be classified in three categories: *RR*, *Rr*, and *rr*. These result in the following types:

RR—right-handed
Rr—ambidextrous
rr—left-handed
Among identical twins:
RR—both members right-handed
Rr—one right-, one left-handed; mirror images
rr—both members left-handed

According to this scheme, genetically ambidextrous persons (*Rr*) are easily shifted by training and other environmental influences. As we live in a right-handed world, many people who are naturally ambidextrous become functional right-handers. Some functional left-handers are undoubetdly genetically ambidextrous, however, which accounts for the observation that in families where both parents are left-handed only about half their children are functional left-handers. Identical twins who are naturally ambidextrous consist of one right-hander and one left-hander, possibly because of the operation of an asymmetry mechanism or position during embryonic development. Persons who are genetically right-handed or left-handed (*RR* or *rr*) are not readily susceptible to training. It is these persons who may possibly become emotionally disturbed because of forced changes. Identical twins of these types are alike in functional handedness. It is the genotype of a pair of identical twins, rather than the time of the

Fig. 2. Print of a left hand, showing pattern in T area. Same individual as in Figure 1.

twinning process, that determines whether they will be alike or different in handedness.

Observations of the incidence of left-handedness among the immediate relatives of twins (their parents, brothers, and sisters) have revealed significantly more left-handers among the families of "mirror-image" and left-handed pairs than among those of right-handed pairs. One such study was made of 343 pairs of identical twins and their families. Over 41 per cent of the pairs consisting of one or more left-handers had left-handers among their immediate relatives, whereas only 16.5 per cent of right-handed pairs had left-handers in their immediate families. This is, of course, what should be expected. Moreover, the palm and finger prints

Fig. 3. Print of a right hand lacking a pattern in the T/I area.

of twins classified according to handedness reveal that mirror-image pairs have less bimanual variation than do right-handed pairs, thus differing in the same manner as do left-handers from right-handers among the single-born. It should also be noted that the mode of inheritance proposed for handedness should lead to the same distribution of handedness among identical twins as expected on the basis of pure chance.

Fig. 4. Print of left hand, showing loop in the T/I area. Same individual as in Figure 3.

The degree to which one's handedness may be influenced by environment depends upon his heredity. This is also true of identical twins. Functional handedness, like the majority of human variations, is an end product of the interaction of heredity and environment. Both are important, and the relative part played by each depends upon the individual. In view of the fact that heredity does play an important part, left-handers should be provided with facilities to express their natural preferences.

SCIENCE ON THE MARCH

NEW U. S. GEOLOGICAL SURVEY MAPS

THE U. S. Geological Survey, striving to complete the National Topographic Atlas of the United States, has several new maps available, including the following:

International Map of the World

Small-scale mapping at 1 : 1,000,000 covering large portions of the country, with explanations in English and French. Altitude of land and depth of sea expressed in meters and shown by graded coloring in brown, green, and blue.

Austin. North H-14. Part of Texas; latitude 28° to 32°; longitude 96° to 102°; $1.00.

Mississippi Delta. North H-15. Parts of Texas, Louisiana, Mississippi, and Gulf of Mexico; latitude 28° to 32°; longitude 90° to 96°; 75 cents.

Cascade Range. North L-10. Parts of Washington and Oregon; latitude 44° to 48°; longitude 120° to 126°; $1.10.

Of the 53 sheets of this series designed to cover continental United States, 12 have been published to date. Two are being prepared for reproduction—Los Angeles and Savannah—within the next several months. Work on the series has been indefinitely suspended.

State Base Maps

This new series, whose publication began in January of this year, is expected to be of special value in teaching, planning, recreation, engineering, and commercial activities. Some of the maps in the old state series had not been revised in more than 40 years. In that time, towns have been abandoned and new ones established, railroad trackage has been discontinued or added, dams have been constructed, local boundaries relocated, national parks added, and many other changes made.

Published early this year were New Jersey; Massachusetts–Rhode Island–Connecticut; Maryland–Delaware; and Wyoming. Available now are Indiana, Iowa, and Mississippi.

The first three are available in three editions: (1) base map, (2) shaded relief, (3) shaded relief with highway overprint and contours. The base maps are priced at *25 cents* and the shaded relief with or without highway overprints are *40 cents*. The scale is 1 : 500,000 or approximately eight miles to the inch. The Wyoming map is available in two editions: base map, *60 cents;* and base map with highways, *80 cents*. Indiana, Iowa, and Mississippi are available in only two editions—no shaded relief. Indiana and Iowa, with or without highways, are *60 cents* each. The Mississippi base map is *50 cents* and with highways, *70 cents*.

Alaska Reconnaissance Topographic Series

Standard size and format distinguish this new series of Alaska Reconnaissance sheets from the previous maps covering heterogeneous areas of special interest.

The following maps of the Territory are at a scale of 1 : 250,000, or approximately 4 miles to the inch; *25 cents* each:

Candle	Juneau
Eagle	Ruby
Healy	Taylor Mountains

Hawaiian Islands

Topographic Map of the Island of Kauai (reprinted). Scale, 1 : 62,500; contour interval, 50 feet. Single sheet, 50 cents.

Washington and Vicinity (Revised)

Demand has remained high for the Survey's 1 : 31,680 map of Washington, D. C., and vicinity, originally published in 1915, revised in 1942. It has been revised again from aerial photographs and by plane table methods for reprinting this year. Contour interval is 10 feet. *75 cents.*

Most of the changes have been in the suburbs. Tremendous housing developments such as Viers Mill Village, Glenmont Forest, Wheaton Hills, and Carroll Knolls in Maryland, Jefferson Manor in Virginia; new highways and a few new public buildings of landmark size have been added.

Topographic Maps, Scale 1 : 250,000

The first of a new series of U. S. topographic maps on a scale of 1 inch equals approximately 4 miles is now being published and distributed by the Survey.

Compilation was begun by Army Map Service a few years ago to meet military requirements, and arrangements have been made now for their reprinting and distribution for civilian use.

In general, each quadrangle map of this series will cover 1 degree of latitude and 2 degrees of longitude or an average of more than 7,000 square miles. The contour interval used will range from 50 to 500 feet depending upon terrain and the source data available. Shaded relief or woodland coverage will be shown on each sheet after consideration of the relative importance of the information and the reliability of data.

When complete the series will contain 469 maps—covering the entire nation. At present, 48 are available at *50 cents* each. A list of these can be obtained from the Map Information Office, Geological Survey.

The following are the latest to be offered:

Brunswick	(Shows part of Georgia)
Los Angeles	(" " " California)
Long Beach	(" " " Calif. and outlying islands)
Santa Ana	(Shows part of California)
Williams	(" " " Arizona)
Flagstaff	(" " " ")
Prescott	(" " " ")
Salisbury	(Shows parts of Maryland and Delaware)
Eastville	(Shows parts of Maryland, Virginia, and North Carolina)

Weed	(Shows parts of California)
Bath	(Shows part of Maine)
Wenatchee	(" " " Washington)
Yakima	(" " " "
Vancouver	(Shows parts of Washington and Oregon)
Jackman	(Shows parts of Maine and Canada)
Eastport	(Shows part of Maine)

Standard Topographic Quadrangles

The following maps are portions of the National Topographic Atlas, designed to cover the entire United States with large-scale mapping in accordance with current national map accuracy standards. The shape and altitude of the land surface are represented by contour lines in brown; water features are in blue; and works of man, including cities, towns, schools, churches, railroads, boundaries, etc., are in black:

Alabama
Oakman
Wiley
Alabama–Tennessee
Salem
Union Hill
Arkansas
Ione
Van Buren
Arkansas–Oklahoma
South Fort Smith
California
Blocksburg
Mount Tom
Petaluma Point
Pike
Tait
Colorado
Erie
Keenesburg
Masters
Idaho
Packsaddle Mountain
Indiana
Georgia
Wawasee
Kansas
Bird City South
Bonner Springs
McDonald
McLouth
Midland
Kentucky
Bordley
Mount Washington
Sebree
Waverly
Maryland–Delaware
Cecilton
Missouri
Benjamin
Camden
Dover
Higginsville
La Belle
Lewistown
Williamstown
Nebraska
Kilpatrick Lake
Marsland
Seneca
New York
Harford
West Bainbridge
North Carolina
Newport
Ohio–Kentucky
Concord
Oregon
Long Creek
Susanville
South Dakota
School Section Butte
Wanblee NW
Tennessee
Brownsville
Campbells Station
Pulaski
Rives
Sunnyhill
Taft
Texas
Grapeland
Kennard
Kennard NE
Washington
Bodie Mountain
Curlew
Kettle Falls
Orient
Republic
Sherman Peak
Waueonda
Wyoming
Coleman Butte
Herman Ranch

Reprinted Topographic Maps

Alabama
Tensaw
California
Altadena*
Castaic
Daulton
Del Sur*
Ducor
Fairmont*
Manzana*
Quail*
Violin Canyon*
Kentucky–Indiana
Prospect
Maine
Portland
Massachusetts
Hyannis*
Washington
Red Rock

* Reprinted with corrections.

Standard topographic maps of the U. S. Geological Survey are available at *20 cents* each. Index circulars showing the progress of topographic mapping are issued from time to time and will be sent free on application to the U. S. Geological Survey, Washington 25, D. C. Available now are new index circulars for Colorado, Kentucky, and Ohio.

Geologic Maps, Sections, and Indexes

Geologic Map of the United States. Edition of 1932 (reprinted). Scale 1 : 2,500,000. Printed in four sheets. Price complete $2.50.

Map OM-115 Geology of the Moon Lake Area, Duchesne County, Utah, by J. W. Huddle, W. J. Mapel and F. T. McCann, covers the surface geology and the structural features of an area about 40 miles west of the Ashley Valley oil field where oil is being produced from the Weber sandstone of Pennsylvanian age. Some of the outcropping beds show evidence of having contained oil in past times. Possible source beds and reservoir rocks are discussed. The map is on a single sheet on a scale of one inch to the mile. Copies are 50 cents each.

Total intensity aeromagnetic maps of 25 Indiana counties, by J. R. Henderson—15 cents each.

Geologic Quadrangle Map Series

Surficial Geology of the Mount Toby Quadrangle, Massachusetts, by Richard H. Jahns, 50 cents.

Bedrock Geology of the Mount Toby Quadrangle, Massachusetts, by Max E. Willard, 50 cents.

Geology of the Mount Tobin Quadrangle, Nevada, by H. G. Ferguson, S. W. Muller, and Ralph J. Roberts, 50 cents.

The complete list of new maps as published by the Geological Survey (about 70 each month) is contained in the monthly pamphlet *New Publications of the Geological Survey*, available free on request. An information folder on mapping; an index to topographic mapping in the United States; and indexes to any of the various states, Alaska, Hawaii, or Puerto Rico are also free on request.

Maps of areas *east* of the Mississippi River may be ordered from the Chief of Distribution, Geological Survey, Washington 25, D. C. Maps of areas *west* of the Mississippi may be ordered from the Distribution Section, Geological Survey, Denver Federal Center, Denver, Colorado.

Prepayment is required and may be sent by money order or check, payable to the ***Geological Survey*** or in cash—the exact amount—at sender's risk. (Do *not* send stamps.) A discount of 20 per cent is allowed on orders for maps amounting to $10.00 or more at the retail price.

GEOLOGY IN THE LIBERAL ARTS COLLEGE

GEOLOGY is a study of the earth in the light of its physical and biological history. It is included in the liberal arts curriculum primarily to afford students the opportunity to study this science under expert guidance, and only incidentally to make available its many excellent illustrations of "the scientific method." The general formula of the scientific method is valid in every field of purposeful research, and students in all these fields should become aware of its many possible adaptations. The teaching of geology offers a good illustration.

As one writer[1] states it, the scientific method is neither mysterious nor complex, but consists of three steps: "1) observation, 2) generalization from the observed facts, and 3) checking the generalization by further observation." The generalization referred to may be a new scientific theory, or it may be a new and better way of teaching. In any event, once a new generalization has been set forth, all interested persons may, and should, join in checking it by further observation (the third step). Those generalizations that presuppose a certain set of conditions may be shown to need revision when that set of conditions no longer prevails. Then the third step becomes a part of Step No. 1, leading to a new generalization. The teaching of geology now needs such re-evaluation.

For teaching purposes, the field of geology became organized in its present form during the last quarter of the nineteenth century, when physical geology, and especially physiography, were coming into their own with such tremendous popular appeal. The new concept of the erosion cycle with its imaginative terminology, along with many related discoveries, enriched the lives of students in a most gratifying way, and the new body of knowledge found a ready place in the academic curriculum. The fashion of teaching geology soon crystallized with the dictum that a person cannot successfully comprehend the historical aspects of geology without first being well grounded in physical geology. This was the generalization reached at that time. Further observation showed that it was a workable plan. It produced many eminent geologists, who contributed much to our further knowledge of geologic processes, which thereupon augmented the physical-geology prerequisite to the study of earth history. The prerequisite continued thus to grow while college curricula expanded on all fronts to keep abreast of discoveries in new fields as well as old, and the new breadth of knowledge made depth of learning more and more difficult. The number of collegiate hours available for the study of geology (and other sciences) was more and more limited, and fewer and fewer students had even the chance to learn about our planet's past.

Meanwhile, geology teachers became concerned with possible ways to condense their subject and to make the most of the student's time. Many of these teachers, however, have not yet questioned the fundamental assumptions regarding course content that they have inherited from their academic grandsires. Some of them regard as heresy any suggestion that reorganization might be advantageous. Even though geology textbooks still faithfully proclaim that geology is a historical study of the earth and of the development of life upon it, the student enrolling in many an elementary course this year must be content with a brief inquiry into the present mechanical and chemical processes of geology, because time does not permit him to study his present world in its geologic perspective. This is not only unfair to the student (though he has no way of knowing it), but also it is a disservice to the cause of geological education in that it implies a false narrowness of scope. The placing of chief emphasis on details of physical processes, with the table of geologic time divisions included as an appendix, all but completely by-passes the central theme of geology. The old generalization has thus led us to the dubious position of claiming that any study of geologic activity is proper "introductory geology" even though it is centered on the periphery of the field. Those teachers who believe that a college course of five or six credit hours can and should give the student a sense of geologic perspective and understanding must therefore place the old generalization, together with all past experience, as Step No. 1 toward a better synthesis.

As a preliminary to re-evaluating geology in our present curriculum, it may be well to ask how Gilbert, Dutton, and Dana (to mention but a few) came to know so much about earth history, having begun their careers before it was necessary to take an extended prerequisite course in physical geology. What was it that aroused and sustained the enthusiasm of Hall, Hitchcock, and a host of others both professional and amateur in those days when so much of physical geology as we now know it was yet to come? Today the very richness of our field may obscure some of its fundamental educational potentialities. It is also a challenge to make its central and fundamental concepts avail-

able to our students. We may begin by re-examining the antecedents of the old generalization.

The belief that an extensive course in physical geology must precede historical study derives its "scriptural" authority from the doctrine that "the present is the key to the past." The soundness of the doctrine cannot be questioned, but in its application we must rely on reason rather than on authority. Though it is true, it is by no means the whole truth. More than one hundred and fifty years have passed since that doctrine was promulgated. Most of the essential physical geologic processes to which it then referred are now common knowledge to most reasonably intelligent college freshmen. They can grasp quickly the basic idea that land-derived sediment is this year becoming a stratified marine deposit in which the remains of organisms may be buried. Hutton, Playfair, and Lyell would be outraged at our modern insistence that a student must learn all about mature topography, offshore bars, kames, and ventifacts, not to mention the abstract geometry of faults and folds, before he should be permitted to learn about the Old Red Sandstone, the Carboniferous forests, and the Caledonian Mountains.

One eminent geologist[2] has recently affirmed his considered belief that the greatest single contribution of geology to modern thought is the realization of the immense length of geologic time. Historical development has always been the essence of geology, and certain achievements in atomic research over the past few decades have increased its significance a hundredfold in making possible a degree of accuracy and assurance in dating geologic events undreamed-of a few years ago. Our earth has come to its present state through a measurable span of time, even though mystery still shrouds its beginning. The professional geologist works and thinks in terms of this historical background, and the general elementary course, even though of only one semester duration, should give the student the best possible chance to contemplate his world in the light of these thoughts. We want all our students to learn what geology is and how a geologist goes about his work. We want them, so far as possible, to share our enthusiasm for the science.

To achieve these results, we should organize our subject matter around the basic concepts of geologic time and change, and straightway proceed to make our students feel at home. Even though their time with us is brief, the richest materials are then closest at hand. With frequent reconnaissance to the border zones of related fields of thought, they quickly learn proper orientation while becoming familiar with the fundamental subject matter. Stated in more specific terms, the principles of physical geology can best be taught in their appropriate historical setting. Earth history and its processes can and should be so interwoven that the student comes to see the present in its rightful perspective. The basic idea is by no means new, but this integration of physical and historical geology has already become Step No. 2 in some of our colleges, and subsequent observations are confirming the feasibility and soundness of the integrated approach.

Presenting the science with the many facets of its twofold aspect integrated into a coherent unit assures the student of a proper introduction to the whole field. This is advantageous to both the general-education group and the future geologists. To a large extent these two groups are not differentiated at that stage. Many a good geologist has begun his career by enrolling in the elementary course primarily to fulfill a science requirement. Nothing less than a full view of the entire field will enable a student to choose intelligently. If he decides to make geology his lifework, he is then in the best position to understand the interrelationships of the more advanced courses and the need for training in the supporting sciences. From the start, he is properly oriented. On the other hand, should he decide to enter some other field, he will at least have had the complete survey of the science that an educated man should have. Nothing less than this can guard against the narrow and inadequate idea of professional geology that so many supposedly educated laymen now have.

That a preliminary working knowledge of rocks and minerals be gained early in the geology course is both logical and psych*ological*. Then with carefully planned discussions of pertinent aspects of the geologic processes the student can begin to use the key that unlocks the past. The spirit and essence of the old doctrine is that the present and the geologic past are inseparably joined. A growing knowledge of either one immediately illuminates the other. The educational aim of geology, both general and professional, is a proper understanding of the present. To the extent that a student learns to view the present in that perspective which only a knowledge of the geologic past can give, *the past becomes the essential key to the present.* Unless this reciprocal relationship is brought out, the student who thus unlocks the past sees only the petrified geologic remains instead of the living record that we know is there.

One of the most underrated problems in the teaching of elementary geology is how the average

student is to gain a sense of familiarity with geologic time. Quite definitely, the immensity of geologic time is not to be treated as merely a fact to be covered in Chapter Z of the geology course. On the contrary, it is a concept that requires months for assimilation, and involves the most drastic revision of the student's previous ideas of both time and change. To acquire a "working idea" of astronomic distance is comparatively easy. Even such aids to comprehension as the fact that annual interest on our national debt amounts to about $2.00 for every year since the earth was created are of but little help at first.* But the concept of time is of prime importance in understanding geology, and a forthright beginning on this problem should be made at the very start of the course. Gradually the high lights of the fossil record become associated in the student's mind with the time-imposed characters of the rocks and with such ecologic conditions as can be deduced from them. In this way a sense of relative time values is built up. Without this comprehension of time, historical geology fails to take on any significant reality.

With constant reference to geographic distribution and to observable processes, the student achieves a proper understanding of why, for instance, the Piedmont region is different from the Coastal Plain, to use but a single illustration. Understanding the development of the coastal plains leads naturally to the more detailed study of shoreline processes, offshore deposits, and the contrasts between Atlantic and Pacific shoreline features and history. Then reference to the Cambrian sea cliff at Devils Lake, Wisconsin, for example, has for the student a richness of meaning it never could have without a good sense of geologic perspective. This kind of background is necessary if the present is to illuminate the past effectively, and with it the student has the best possible preparation for detailed study of present geologic processes.

Postponement of detailed studies of such topics as shorelines, glaciation, and topographic history until late in the course has enormous advantages for the student. His initial interest in minerals and fossils will carry him through the most difficult and tedious parts of the course. He realizes that his earth has had a history, with a succession of sea invasions and episodes of orogeny. The topic of rock structure is an integral part of these studies and helps to give reality to the historical record. Moreover, it is saved from becoming a meaningless memorization of encyclopedic terminology. Folds, faults, and unconformities are a part of the record.

* In time, this measuring device gives students a better comprehension of the national debt!

Appreciation of topographic development is always relatively easy to instill, and this background of geologic history intensifies the student's enthusiasm for topographic studies. He will not know all the details of regional geologic history, but he will be able to understand whatever reference to them the teacher may wish to make. Classroom discussion is then on the basis of one geologist speaking to another. Such experiences, coming late in the course, bring a sense of achievement and satisfaction that persists past the final examination. This is quite in contrast with the common reaction of students who spend the last few weeks of the course in a desperate struggle with the new concepts and unfamiliar terminology of earth history. It seems to them like an entirely different subject, and the time available is woefully inadequate for proper assimilation. They leave the final examination with the fervent hope that they may never again have to hear anything about the Paleozoic.

Such unhappy endings may well be one important reason why there are so few popular books on geologic subjects in spite of the fact that a fair proportion of our college graduates have had elementary courses in geology. Another reason is that so many of these courses cover only (or largely) physical geology, and the student has therefore no background for appreciating earth history, which is a vital element in anything a real geologist would write.

Study of the Pleistocene in its proper historical setting is particularly effective. Pleistocene orogeny and earthquakes, Pleistocene glaciation and vulcanism, these are the valid geologic circumstances that account for the fact that most of earth's spectacular scenery is of Pleistocene development. This historical-geologic approach to the record of the past million years, rather than the time-sterile physical-geologic, likewise brings out in true perspective the geologic history of man. It prepares the way for the final step from geologic history to recorded human history now made possible by recent research with radiocarbon (carbon 14).[3]

The historical approach also avoids the bewilderment of the student who asked, when studying the Pleistocene in the conventional physical-historical sequence: "Are these glaciers the same as those we studied back in that other chapter?" His confusion is understandable. If geologists themselves carefully segregate present earth features and processes from their historical development, the student is surely placed at a disadvantage.

Discussion thus far has had chiefly in mind the interests of the general-education group, which comprises perhaps 98 per cent of an average ele-

mentary class. Experience with the integrated approach justifies two further conclusions regarding the preprofessionals. One conclusion is that the integrated course does provide an adequate basis for advanced study. The old argument that such preparation must consist of an extensive study of physical geology, to the exclusion of the historical, has no logical support. The second course or courses should begin where the first one ends. After all, the curriculum is supposedly designed for the benefit of the student, and not with the idea that the student's welfare and progress must be cramped into an arbitrary curriculum. Whether the introductory course is for one semester or two, the student can make only so much progress in a given time. Sound initial orientation in a science so diversified as geology is the best possible preparation for a maximum rate of progress in the advanced courses.

The second conclusion, already suggested in an earlier paragraph, is that the future geologist should be keenly aware of the cultural or humanistic value of his chosen science. In technological schools, cultural values may have to be left largely for the student to acquire independently; but a liberal arts education requires (or at least assumes) that cultural values be given due consideration. These two types of scholastic background supplement each other in practical work, and the profession needs both types of trained personnel. The elementary course is the time and place to introduce cultural possibilities, and a complete survey of the field offers maximum opportunity. In fact, the elementary course that slights earth history leaves untouched the most vital philosophical contributions that geology can make to modern education. Here again, once the student is properly oriented and introduced to fundamentals, his further growth in this aspect of science is well assured. His later courses automatically amplify a pattern sketched in the elementary course.

Bearing on this phase of geology is the common assumption that any emphasis on cultural value in an introductory science course tends to nullify its preprofessional effectiveness because, according to the assumption, such a course is necessarily "sugar-coated" or "watered-down." This unwarranted verdict seems to be a defense mechanism of those who fear they will not be thought of as rigorously scientific, and who arbitrarily brand anything cultural as effeminate. Any course *can* be "watered down," but no college course worthy of credit need be. The task of bringing into focus the human significance of scientific knowledge requires intellectual effort and teaching skill of the highest order.

In summary: The pressing need for more and better education without extending unnecessarily the time devoted to it requires careful planning to the end that learning shall be more efficient and more effective. In geology, one of the greatest obstacles to maximum achievement is in bridging the artificial gap between physical and historical geology. The integrated course as suggested in the preceding paragraphs not only avoids that artificial handicap of segregation and obscure duplication but also places the student in immediate contact with the central, fundamental concepts of geology. For both the prospective major and the nonmajor, the integrated course is the most efficient and desirable introduction to the subject. With this approach, no student can be left in ignorance of any significant part of this inspiring field of knowledge.

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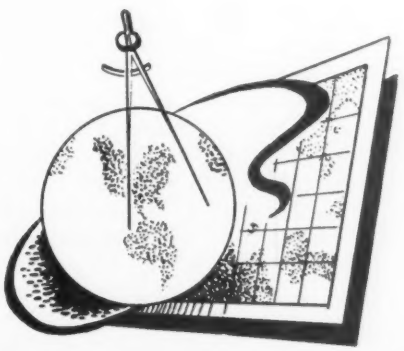

BOOK REVIEWS

FORESTRY'S ANNIVERSARY

Fifty Years of Forestry in the U. S. A. Robert K. Winters, Ed. x + 385 pp. Illus. $4.00. Society of American Foresters, Washington, D. C. 1950.

FIFTY YEARS OF FORESTRY IN THE U. S. A. is of interest not only to the scientist, but particularly to the general reader, in that forestry has been the spearhead of the movement that is changing the public viewpoint of the American dwellers on "our plundered planet" (as Fairfield Osborn puts it) from ruthless destruction of supposedly "inexhaustible" natural resources to conservation of such as are left.

The book was prepared by a committee of nineteen members of the Society of American Foresters to mark the society's fiftieth anniversary, and is in nineteen chapters, each by a specialist in the subject covered. All are easy for the nonprofessional reader to understand, and some make extremely interesting reading. In short, it is a very good book, as well as a record of outstanding accomplishment and of necessary future action.

The book shows that, viewed against the background of the situation at the turn of the century, the development of forestry in the United States has been extraordinary. The richest forests in the world were disappearing like a snowball in the sun, before attacks by axe and flame pushed with a ruthlessness unparalleled in history. Forestry as a science was practically unknown.

Such was the situation when Gifford Pinchot, the first American forester (but trained in Europe), and Henry S. Graves (also trained in Europe) appeared on the scene. In 1898 Pinchot became head of the Bureau of Forestry in the Department of Agriculture, with Graves as his assistant. In 1900 Pinchot, realizing the need for foresters trained in America, founded, with an endowment provided by his family, a postgraduate school of forestry at Yale and induced Graves to become its first dean. This, owing to Graves' outstanding ability, was one of the most important steps contributing to the remarkable advance of American forestry. There are now twenty-two accredited forest schools in the country, three of which are postgraduate; 13,504 undergraduate, 2,460 Master's, and 148 Doctor's degrees have been conferred.

It was also in 1900 that Pinchot started the Society of American Foresters with seven members; in December 1950 there were 7,038 members (6,500 in 1949).

In 1905 the Forest Reserves were transferred to the Forest Service, renamed the National Forests, protected against fire and theft, and opened to use under forestry principles. The bitter hostility of local people was overcome and turned into strong support of the Forest Service. The National Forests now contain a net area of some 180,000,000 acres, including those in Alaska and Puerto Rico.

Fire protection has developed a remarkable degree of technical efficiency and has been extended, through cooperation among the Forest Service, the states, and private owners, to cover 470,000,000 acres, leaving still unprotected 130,000,000 acres, on which more than half the total number of fires occur.

An increasing number of private owners are coming to realize the advantages of treating their forests as a renewable crop, and a good many are employing professional foresters to place their lands under proper management.

Although progress has been great, much more remains to be done. There are still far too many fires caused by human carelessness. Protection against insects and disease must be very much improved. Destruction still continues. A survey shows that only 8 per cent of the cutting on private lands can be classed as good, 28 per cent fair, and 64 per cent poor or destructive. The most difficult problem is the 4,250,000 small owners who have an average of only 62 acres each, but whose total holdings comprise 261,000,000 acres, or about 75 per cent of the private commercial forests of the country. A great deal of effort has been expended in education and free advice, but progress has been painfully slow.

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AMERICAN PREHISTORY

Contributions to American Anthropology and History. Vol. X. 186 pp. Illus. $4.00, paper; $4.50, cloth. Carnegie Institution of Washington, Washington, D. C. 1949.

OF THE four contributions in this volume, all except one fall into the field of Maya civilization and history, i.e., the special field of interest of the Division of Historical Research of the Carnegie Institution. A. V. Kidder's and H. S. and C. B. Cosgrove's "The Pendleton Ruin, Hidalgo County, New Mexico" is a useful addition to our knowledge of the archaeology of the American Southwest, even though, in Kidder's words, the excavation "produced no startling results." The largest of the three other contributions is that by Barrera and Morley called "The Maya Chronicles," in which the authors develop more fully points of view on Maya historical traditions and history presented by them in earlier publications. The novel and the most important part of this monograph is the attempted reconstruction of the original texts of the various chronicles by Barrera (fully subscribed to by Morley). Valuable as this attempt is, it is open to criticism in several respects, principally in that a number of possibly significant differences tend to disappear in Barrera's reconstruction. Actually, each of the chronicles (and versions thereof)

may very well itself be a composite of several original sources that late compilers have "strung together" in one sequence, as Eric Thompson suggested some years ago. This interpretation would explain the frequent and puzzling repetitions, as well as contradictions, in these chronicles. My recent discovery of parallel calendars used in each of the member-states of the League of Mayapan now makes it possible to separate the various fragments that have been combined into each chronicle as it is known today. Such a discriminating and, at the same time, realistic utilization of the data, and especially the dates contained in the Maya chronicles, will, in my opinion, obviate the need for such artificial and forced interpretations as that of Morley when he says (p. 72): "I believe that the portents of this particular katun [the 20-year period ending in a day 8 Ahau, recurring every 256 years] eventually became so heavy that in time they literally influenced the course of Maya events; that the Maya themselves finally came to await the return of Katuns 8 Ahau in order to make important changes in their group affairs, such as waging wars on neighboring states, abandoning old capitals, and founding new ones"—an interpretation for which Tozzer, I believe, has coined the appropriate phrase of "a belief in chronological neurosis."

In the next contribution Ralph L. Roys has given a very useful "Guide to the Codex Perez" (not to be confused with the so-called Codex Peresianus, a pre-Spanish hieroglyphic manuscript in the Bibliothèque Nationale in Paris), which consists of abstracts copied about a century ago by one Juan Pio Perez from a number of Yucatecan manuscripts of the sort now known as Books of Chilam Balam. Roys' "Guide" consists of two parts, a descriptive and analytical introduction and an annotated table of contents, both done in a highly scholarly fashion, which should be very useful to all future students of the important materials contained in the manuscript.

The last contribution, likewise by Roys, called "The Prophecies for the Maya Tuns or Years in the Books of Chilam Balam of Tizimin and Mani," is the most important of all, since it gives the first annotated English translation and analysis of the outstanding example of the most interesting material in all native Maya literature, the so-called prophecies. Some of the "prophecies" that have come down to us refer to pre-Spanish events, others to the Spanish conquest and the introduction of Christianity. It is important to stress the fact that in either case these were past events by the time they were written down in the sixteenth century by natives who had learned to use the European alphabet.

All Maya prophecies speak of events as going to happen at some specified time, either rather vaguely in a certain katun (i.e., a period of 20 tuns, or short years of 360 days each) or, more precisely, in one of its tuns. This precision has aroused the suspicion of modern scholars, who have concluded that in some cases, especially those dealing with events connected with the coming of the Spaniards, we are dealing with post-factum predictions (if such an expression is permissible). I would go much farther and argue that *all* Maya prophecies that predict events for certain katuns or tuns are of such a nature. (The day-by-day prophecies appear to be of a different type, since they do not predict individual events but rather types of events that are to happen on certain days.)

More revealing still than the chronological precision is the orderly and apparently correct historical sequence into which prophesied events fall. In the case of the katun prophecies this sequence is often distorted by the fact that they are repetitiously told in terms of the calendars of different city-states. But the prophecies presented and analyzed here by Roys are of a different nature, in that they predict events for every one of the 20 tuns of one single katun, obviously in terms of one single calendar. The events described seem to fall into a consecutive story, and even though they are told in the future tense it is difficult to get away from the impression that what they give us is a fragment of actual Maya history, narrated in the form of prophecies. In his analytical introduction Roys states that among the many personages mentioned he has been able to identify only two with historical personages known from other sources. In his footnotes, however, he has identified several more (see notes 77, 123, 132, 199). And in note 155 he points out that the expression "joint government," which the text uses, is in other sources employed in connection with the fall of Mayapan. Actually, it would seem that this is a reference to the type of government characteristic of the League of Mayapan during its whole existence, and that this particular set of prophecies refers to the *beginning* of the League, which in my interpretation coincides with what Roys calls the "Hunac Ceel Episode." Indeed, one of the two personages that Roys in his introduction recognizes as historical is, in another source, the Book of Chilam Balam of Chumayel, associated with this event.

The conclusion to which this and other considerations have led me is that this particular set of prophecies actually is a historical account of events connected with the fall of the League of Chichen Itza—that is, the defeat of the Itza, and the setting up of its successor, the League of Mayapan, detailed proof for which I expect to present elsewhere. Here I want to mention only a very interesting regularity that I have been able to detect in this narration. Every time a personage is mentioned whose name contains an element like "snail," "shark," "crocodile," "mottled snail," etc., or the element *chac*—that is, "red" or "great"—it is a personage who suffers defeat or undergoes some kind of hardship. The world quarter in which Chichen Itza was located was in Maya symbolism associated with the color red, and in one Maya chronicle the king of that city at the time of its defeat is called "Red Rain-god." Names with elements like "crocodile" or "shark," on the other hand, are in many sources associated with the northern quarter. I would submit, then, that all these personages represent the defeated Itza of the east and their allies in the north. On the other hand, names like "11-Spider" or "7-Centiped" appear to be uniformly those of indi-

viduals who inflict sufferings or defeat on others and would, therefore, seem to represent the triumphant forces of the west and south that defeated the Itza of the east and set up the new League of Mayapan. If this interpretation is correct, the series of prophecies studied here, which are truly crammed with names and events, would turn out to be the most vivid and detailed historical narrative in existence, not only for Yucatan but also for any other part of native America, covering a twenty-year period of key importance in the history of the Mayas of Yucatan.

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COMPLEX PHENOMENA

Cosmic Rays. Louis Leprince-Ringuet. Fay Ajzenberg, Trans. xii + 290 pp. Illus. $6.65. Prentice-Hall, New York. 1950.

THIS book should be considered as neither a convenient reference nor a text, but rather as an extremely interesting account of the present state of knowledge of the origins and nature of the complex phenomena of cosmic radiation by an outstanding authority in the field. Although the primary emphasis is on cosmic radiation itself, Leprince-Ringuet has included pertinent results of recent work with high-energy accelerators, now so closely related to cosmic ray research.

The least satisfactory sections of the book are the three opening chapters, intended to provide background for the lay reader on fundamental concepts and methods of corpuscular physics. One suspects that, although the author appreciates the necessity of laying this groundwork, he is too anxious to plunge into his subject to take care in the preliminaries. A reader unfamiliar with the vocabulary of this field will be confused, not enlightened, by this material, which begins at a high level, drops to a low level, then rises to a high level again; he will be particularly bewildered by equations whose derivations are not given, whose symbols are rarely identified, and which are not essential to an understanding of the subject. The remainder of the book is generally, though not entirely, free of this criticism. However, this fault in the beginning makes the book suitable only for readers with a good background of physics.

Leprince-Ringuet is at his best when describing actual experiments and methods. The chapters on early history, on techniques and results of high-altitude research, and the final chapter on The Personality of Cosmic Radiation are interesting and informative, and, because they describe so well the nature of pure research and the fascinating adventures it can sometimes provide, deserve wider reading than the scope of the text will allow.

Chapters on the latitude effect, on cascade showers, and on nuclear effects are very thorough. The treatment of meson theory in Chapter 13 is an unusually good presentation of a difficult subject.

The attitude underlying the author's approach to the subject should be evident from his comments on the neutrino: ". . . a curious particle. Experimental physicists . . . are reluctant to admit the existence of a particle that they cannot actually detect with instruments. Theorists, on the other hand, can attribute various characteristics to the neutrino without fear of soon being proven wrong by experimental data."

Except for several astonishing sentences (e.g., "When a screen is placed in a Wilson chamber bathing in a magnetic field. . . ."), the translation is accurate. The illustrations, which are numerous, appropriately chosen, and well explained, are an outstanding feature of the book.

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THE PLANT KINGDOM

Botany—An Evolutionary Approach. R. Darnley Gibbs. xiv + 554 pp. Illus. $6.00. Blakiston, Philadelphia. 1950.

Introductory Botany. Alexander Nelson. viii + 479 pp. Illus. $3.75. Chronica Botanica, Waltham, Mass. 1949.

IT IS interesting to compare these two textbooks, which represent the teaching of botany in universities of Canada and Great Britain, respectively, both with each other and also with current American college textbooks. In format the two show a vast difference. The book from McGill University has a characteristically American format. It is large (8″ × 11″), printed in two columns, and illustrated with an abundance of excellent half tones. The British book looks small and old-fashioned beside it and has no plates or half tones, but the excellence of its line cuts makes up for these inequalities. As to text, both books are written in a factual, compressed, and undistinguished style. The result may be described as clarity tempered by dullness. This effect is heightened by the emphasis on morphological terminology.

More serious criticisms may be leveled at the lack of modernity in treatment of the subject. Both authors aspire, according to their own words, to "present the subject matter whole on a theme of adaptation and evolution" (Nelson), or to use "an evolutionary approach" (Gibbs). Yet Nelson dismisses the general consideration of evolutionary principles in two pages, then leaps into the morphology of monocotyledons and dicotyledons, evidently his true love. Gibbs' concept of an evolutionary approach is to survey the plant kingdom, beginning with the blue-green algae, and to conclude with a chapter on plant geography, and one on evolution and genetics. The classification used by Nelson is classic, with certain omissions—of the blue-green algae, for instance. Gibbs has adopted a modern taxonomic revision that is much more realistic. But neither author has taken account of recent developments in bacterial cytology that cannot fail to alter fundamentally our ideas of the relationship of this group to other plants; and the re-

marks about the bacterial nucleus (or, rather, the lack of it) are antiquated. Nelson includes a considerable section on plant physiology that is lacking in Gibbs' book; and Gibbs has devoted chapters to plant behavior and to ecological and soil relationships, subjects almost ignored by Nelson. Genetics is treated in rudimentary fashion in both. One can hardly say that either book is adequate for a broad and general coverage of botany.

Gibbs' "evolutionary approach" in particular merits criticism. Paleobotanical material is richly included, but how can a student be expected to grasp the nature of evolution from a survey of the plant kingdom that defers all discussion of evolutionary processes to the final chapter? And devotes only a few pages to it at that? Nowhere are the major evolutionary changes, such as those involved in the shift from an aqueous to a terrestrial habitat, or from a dominant gametophyte to a dominant sporophyte, or in the evolution of the seed and the flower, clearly set forth. A far truer "evolutionary approach" to botany is to be found in Coulter's graphic *Story of the Plant Kingdom*, a classic of which Gibbs seems to have been unaware; or, again, in the relevant section of *The Science of Life*, by Wells, Huxley, and Wells, which readably compresses the salient features of plant evolution into a brief compass. Surely the first obligation of an author who adopts a particular approach is to acquaint himself with the best models of the sort, and then to endeavor to improve upon them. A handsome dress only serves to call attention to an ill-favored form.

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FOR BEGINNING STUDENTS IN RELATIVITY

Mathematics of Relativity. G. Y. Rainich. vii + 173 pp. $3.50. Wiley, New York. 1950.

RAINICH'S book is an introduction to special and general relativity intended for beginning students in the subject. It develops the usual physical and mathematical concepts in easy steps, with gradually increasing complexity. Besides the conventional topics it also includes an original unified theory of the gravitational and electromagnetic fields extending within the framework of a four-dimensional Riemannian space.

The subject matter of a book like this should particularly appeal to the electric power engineer who, these days, is called upon to design billion-volt synchrotrons in which the relativistic effects are all-important. A book of this type would also appeal to the electric power engineer who is called upon to solve his steady-state rotating machine problems or transmission-line loading problems by tensorial methods and who would like to find out more about the philosophy that encourages scientists to employ tensors in basic physical reasonings. The younger members of the electrical engineering profession, who are exposed in studies on the stability of transmission systems to such esoteric concepts as the Riemann-Christoffel curvature tensors of non-Riemannian spaces rigged up with nonholonomic reference frames, should offer a fertile ground in which many of the basic concepts developed in this text could be disseminated.

The present reviewer has spent the past quarter of a century studying or scanning all appropriate books and periodicals for the purpose of finding treatises on tensors and on relativity, written by authorities on the subject, who may have had in mind also the practical needs of the engineer, in addition to the philosophical interest of the physicist. But all to no avail. The author of this book also ignores the existence of that crying need and chooses to address only the theoretically inclined student of physics.

Even a few minor concessions on the part of the author would have helped to bridge part of the gap stretching between practical and theoretical needs. In this age of radar it will strike many readers as odd to see the components of the electric field E still denoted by the archaic *X, Y, Z,* and those of the magnetic field H by *L, M, N*. The author still represents the components of a tensor of rank two by an "array" and grants admission to determinants, but not to matrices. The book would have been greatly improved, even in the eyes of students of physics, by introducing transformations of reference frames through means of matric manipulations.

Nevertheless, there are many important features that greatly compensate for the lack of any conscious effort at practicality. Of particular interest to the student of electrical engineering should be the unusual development of the concept of tensor. Careful and detailed analysis is given for the definition of tensors in terms of multilinear functions of vectors, so that a tensor becomes independent not only of the reference frames used but also of the components assigned to it. This definition of tensors happens to be the basis of the tensorial method introduced for the analysis of stationary electrical networks and transmission systems, in which the functional dependence of the i^2r and i^2x losses upon the current and voltage vectors defines the impedance tensor. Very few introductory textbooks assume this mathematically basic point of view of tensors.

Another particularly helpful feature is the gradual and straightforward development of a geometrical picture of the curvature tensor from a curve in a plane to four-dimensional space-time. In electrical transmission systems the curvature tensor is a measure of the inherent ability of the generators to stay in synchronism. With the present-day accelerated planning of long-distance transmission systems their stability becomes of increasing concern, and the young electrical engineer must get acquainted with the mysteries of the Riemann-Christoffel curvature tensor early in his career if he intends someday to tackle successfully and economically these stability problems looming threateningly on his horizon. The reviewer knows of no other place where an easier and less painful introduction to this all-important physical concept may be acquired than in this book. It is true that the electrical engineer needs rather a physical picture of

the non-Riemannian and nonholonomic form of the curvature tensor, and that consequently a geometrical acquaintance with a simplified form of it is of little practical use to him; nevertheless, the ideas of the present book do represent a start for him in the right direction. The electric power system and its stability problems will be around for a long time yet.

Every page of the book bears the stamp of a long and painstaking pedagogical effort to present to a beginner in the simplest possible manner highly advanced geometrical and physical concepts, without sacrificing any mathematical rigor. While the topics on tensors may be studied profitably by the electrical power engineer versed in Ohm's and Kirchhoff's laws only, the sections on relativity require some acquaintance with the field equations of Maxwell.

The last chapter, on gravitation, will receive little sympathy from the electrical engineer. But let him take heed. He may yet live to see the day when his job will be threatened by some up and coming "gravitational" engineer. The new ideas related in this book did start an industrial revolution within the lifetime of their originator and did introduce the "nuclear" engineer, who already begins to compete for jobs with the electrical engineer.

What a pity that the electric power engineer still does not realize that his whole future is intimately woven into the fabric of the highly theoretical ideas of modern physics. Some of them are presented in this book in such a simple manner that even an electrical engineer can understand, and should understand. But does he want to understand? This reviewer doubts it.

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RESEARCH IN AGING

Trends in Gerontology. Nathan W. Shock. ix + 153 pp. Illus. $2.50. Stanford University Press, Stanford, Calif. 1951.

THE timeliness of Dr. Shock's survey of gerontology in the United States and abroad is attested by the fact that the reviewer has had several requests during the past few months for just such material. Each of these came from administrators who were concerned with such questions as to where research on aging is being done, who is doing it, and what trends, if any, exist in gerontological research.

Preparation of the book could only have been a labor of love. The activities in gerontology are widely dispersed. Except for a few major centers (documented by Shock), research on aging is at present a highly individual pursuit. This, to some extent, Dr. Shock deplores. Indeed, his principal recommendation is that a national institute of gerontology, presumably within the framework of the U. S. Public Health Service, be established.

As a matter of principle, it is difficult to greet this recommendation with any measure of enthusiasm. To establish a gerontological institute is to organize research on aging. Organization, by definition, means loss of individuality, and the latter is essential to creative research.

Exception may be taken, also, to Shock's definition of aging: "All living matter changes with time in both structure and function, and the changes which follow a general trend constitute aging. Aging begins with conception and ends only with death." This definition would make gerontology the fourth dimension of biology. It is not what we think of as aging in the literal sense and it might be wiser to distinguish between the growth phases of the life cycle and those phases characterized by progressive, time-conditioned loss of function. The latter *is* aging and is the phase of the life span with which modern gerontologists are preoccupied. Aside from these comments, which are, of course, a matter of opinion, Dr. Shock has done a first-rate job of surveying modern gerontology, and his book is certain to be generally useful.

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THE FLIGHTLESS BIRDS

Sexual Behavior in Penguins. L. E. Richdale. xiii + 316 pp. Illus. $5.00. University of Kansas Press, Lawrence. 1951.

THIS detailed monograph is based on ten seasons of intensive field study of the sexual behavior of penguins on the Otago Peninsula, New Zealand. Most of the observations were made on the yellow-eyed penguin, *Megadyptes antipodes,* but some data on the erect-crested penguin, *Eudyptes sclateri,* and the little blue penguin, *Eudyptula minor,* are included. The term "sexual behavior" is used in a very broad sense, including relations between members of the same or opposite sex and activities of an aggressive as well as of an "amorous" nature. From the beginning, wherever possible, the birds studied were marked with aluminum bands on which numbers were stamped in four places, making it possible to identify individual birds from any angle at a distance with binoculars.

In the yellow-eyed penguin pair-formaton takes place at any time of the year, but the majority of mated pairs are formed in the winter. This seems to be the case in other sedentary species of penguins as well, but it can hardly apply to the migratory forms, as they spend their "off-season" wholly at sea. Inasmuch as nine of the seventeen species of penguins are migratory, and seven are probably sedentary, there is obviously much room for differences in this regard.

During the first few days ashore at the breeding site before the first egg is laid, the birds are said to be in the "pre-egg stage" (a not-too-happy phrase in the opinion of the reviewer, although it does seem to circumvent the old question as to which came first, the penguin or the egg). Usually the male birds arrive

ahead of the hens, although some females arrive before some of the males, and even before their own mates in some instances. Migratory species of penguins appear to fast throughout the pre-egg stage, but not the sedentary ones such as the yellow-eyed penguin. Coition takes place frequently and until just before the eggs are laid, although in some individuals the pre-egg stage was quite strictly divided into an earlier precoition stage and a later coition stage.

The author uses a term "unemployed" for all penguins which at the time of a given observation are without eggs or chicks when other individuals do have them, including breeding birds that have lost their eggs or chicks. In the yellow-eyed penguin Richdale distinguishes no fewer than 12 distinct categories, exclusive of young birds. Richdale uses the term "love-habits" to include any behavior not of an aggressive nature adopted by one sex toward the other, regardless of time of year and condition of body. Love-habits with pair-formation value occur among unemployed penguins at all times of the year, and in the breeding season are confined to unemployed birds. Love-habits with social value occur among all types of penguins at all times of the year. The causes of unemployment are nonattainment of breeding age, an unbalanced sex ratio, and loss of mate, eggs, or young at the breeding season.

As soon as the clutch of eggs is complete the male takes charge of them, but the sexes alternate in incubation. Out of 889 inspections in the yellow-eyed penguin, the female was incubating 460 times and the male 429 times. After the eggs hatch the parents share equally in watching and feeding the young. The chick stage is divided into "guard" and "post-guard" stages, the difference being that in the earlier stage one parent is always on hand with the young, whereas in the later one both old birds are absent gathering food during the day and both remain with the chicks during the night. Family life in the post-guard stage may be either communal or individual, according to species, but in the yellow-eyed penguin the chicks "group up for company's sake, but are fed as a family unit."

The volume has three indices—to subjects, to species, and to the numbers on the bands of individual birds discussed. It packs within its covers a most remarkable amount of accurate, critical, and new observations on a highly interesting group of birds.

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EARTH'S LARGEST OCEAN

Geography of the Pacific. Otis W. Freeman, Ed. xii + 573 pp. Illus. $10.00. Wiley, New York. 1951.

A BOOK such as this has been long overdue. Anyone who has tried to teach a course in the geography of the Pacific Islands is aware that treatments of the Pacific in most geography texts are inadequate, probably a reflection of the state of most geographers' knowledge of and interest in the Pacific. The war has changed that, and both knowledge and interest have been adequate to stimulate and make possible the production of a book of this kind, a regional geography of the largest region on the earth.

The scope of the book is grand indeed. It "deals with the mightiest of all oceans, its climates, currents, and features, together with the islands that rise above its surface and the people, resources, and industries found in these lands." The list of contributors is impressive, including several of the most important names in contemporary Pacific science. There are chapters, either by the editor or by his collaborators, on the geographic settings, the native peoples, exploration and mapping, trade, transportation and strategic location, and on fourteen island areas, including Australia.

The planning and arrangement of the book are good, and its subject matter is carefully selected. The chapters are somewhat uneven, both in quality and organization, and the type of coverage is not identical for the different regions, as would be expected from such a diverse lot of contributors. The book is inclusive, and as complete as it would be easy to make it without its becoming encyclopedic and unreadable. So comprehensive is it that there is little doubt that it will serve as the standard reference book, as well as textbook, on the Pacific for some time to come. Its use as textbook will, however, be greatly decreased by the fact that it sells for $10. Many instructors will place two copies on the reference shelf rather than ask their students to spend such a sum.

A book that is bound to be accepted as authoritative in its field should be critically examined for accuracy and dependability. To justify such a rating, and also such a price, it should be meticulously accurate and reliable. It should be well edited and well manufactured. A careful scrutiny of this book from these viewpoints brings a distinct disappointment. In an authoritative reference book one should not find that Polynesia is "5000 miles from north to south and 400 miles from east to west" (p. 7); that there are manatees in New Guinea (pp. 39, 160) and iguanas in various islands in the western Pacific (pp. 160, 242, 278), or that the iguana is a "small" lizard (p. 278); that *Pisonia grandis* is a "hardwood" (p. 278); that there is yellow fever in the south and west Pacific (p. 273); that "the niaouli (*Melaleuca viridiflora*) is a shrub eucalyptus" (p. 193); that the "sial or andesite line" . . . "marks the edge of the continental shelf;" or that sennit is derived from coconut "leaves." One wonders what is meant by "coco" on pages 229–230, by "group-up coral and shells" on page 241, or by "the extreme flatness of the floor of the lagoons" of coral atolls on page 31. The substitution of "Peru Current" for the well-known Humboldt Current does not seem either warranted or desirable. What possible objection can there be to commemorating the founder of modern geography? Typographical errors, such as the substitution of "Neon" for Maen Island, Truk, on page 297, "Morotini" for Marotiri on page

364, "northwest to southwest" on page 367, duplication of footnotes and omission of one on pages 418 and 419, and "Titus" Bering on page 71, are all too abundant.

Such mistakes are liberally sprinkled through the greater part of the volume and seriously mar it as a dependable reference source. There might be an excuse for a few such, but their abundance is evidence of hasty writing and careless editing. It is only fair to remark here that Kenneth Emory's excellent chapter on the native peoples seems completely free from such errors.

The book is well illustrated with photographs. Rather mediocre judgment is evident in the selection of these, but their reproduction is something of which the publisher should be ashamed. In a $10 book the quality of the illustrations should be of the best. There are a number of maps, and most of them are quite clear, though often of very small scale.

The bibliographies at the ends of the chapters are extremely useful, though sometimes one wonders about the basis of selection.

Potentially this book is extremely useful. It is hoped that the publishers issued a very small first edition, so that it will soon be possible for the editor to go over it critically to eliminate errors from a second edition. It is hoped, also, that the publishers may see fit to price the next edition within the reach of college students. The increase in sales would undoubtedly make such a policy pay.

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EVER-OLD, EVER-NEW SUBJECT

Climate in Everyday Life. C. E. P. Brooks. 314 pp. Illus. $4.75. Philosophical Library, New York. 1951.

THIS book, aimed at the general reader, differs in many respects from others on climate, but chiefly in its emphasis on the practical side. The author deals with everyday problems with very little preliminary technical discussion on climatology. No words are wasted, for he chooses to treat the subject on a world basis, which is almost impossible to do thoroughly in a volume of average size, as he freely admits, but he has succeeded in compiling and presenting, in an interesting manner, an amazing amount of useful information. Few men are as well equipped for such an undertaking. In a long and distinguished career in the British Meteorological Office, Dr. Brooks has earned an international reputation for his writings on climates in all parts of the world, and especially for his work on climate through the ages.

The book is divided into three parts. The first, Living with the Climate, occupies about half of the book. Here the author discusses the economics of climate and the siting and design of houses and factories, giving useful data, formulas, and quantitative indications where possible; after that he takes the reader in seven-league boots for a glance at the climates of the world. The second part, Climate as an Enemy, treats deterioration of materials, atmospheric pollution, and climatic accidents (hurricanes, floods, ice storms, etc.). Here, too, he compresses a great deal of useful data into a small space. The short section on atmospheric pollution, for example, could be expanded profitably to a volume in itself. The third part, The Control of Climate, deals with a fascinating subject, but it is condensed to little more than an interesting summary of man's efforts to gain mastery of the weather.

The purpose of the book is to help the reader make the best of the climate in which he lives. It is the only book devoted exclusively to a survey of this special field, and the author accomplishes his purpose admirably in spite of space limitations. Here and there the reader comes upon an obvious slant toward British experience (which is not unexpected, for the book was published also in London), but Brooks makes a special effort to incorporate the everyday effects of American weather, with its great variability and violent extremes—so different from the maritime climate of the British Isles.

One of the three appendices supplies useful climatic tables for representative places around the world.

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YEARS OF A BOTANIST

An Illustrated Manual of California Shrubs. Howard E. McMinn. xi + 663 pp. Illus. $6.50. University of California Press, Berkeley and Los Angeles. 1951.

"THERE'S nothing worth the living but laughter and the love of friends," according to the philosophy of Hilaire Belloc. To this we might add that among earth's innumerable varieties of flora and fauna is to be found a vast array of new friends with every discovery of something previously unknown or unnoticed. There is nothing quite as exasperating or boring to the average person as to be left suddenly at a lonesome crossroads railway station in the middle of nowhere with nothing to do but wait four hours for the next train through, as your reviewer and 600 other soldiers once were. It was a surprise then, but it never will be again, to find that the hours passed like a whirl of dust as three of us did a bit of botanizing in new territory.

Fortunately for those who care, there are men like McMinn, willing, even eager, to do the painstaking and sometimes tedious work of classifying and naming the earth's plants. The avowed object of his book on the shrubs of California is to provide a working manual for the identification of woody and semiwoody plants (except trees and cacti) for the forester, ranger, traveler, vacationist, teacher, landscape designer, gardener, and student of nature. But it will prove equally valuable to the professional botanist who may be interested in shrubs of the Southwest. California's lengthy stretch of 775 miles from Oregon to the Mexican border embraces such a wide variety of climate that the description of about 800 species and 200 varieties covers more than the Poppy State and requires a book as thick as Sargent's *Manual*

of the trees and shrubs of North America (a puzzling omission in the author's bibliography).

Among professional taxonomists there will be considerable disagreement over the recognition accorded to some species and not to others. Many will object to some of the woody cushion plants and half-shrubs included, as well as to some of the nomenclatorial changes. But on the whole it is a work the author can be proud of in any company. It shows without searching the result of more than twenty years of botanizing, in which he visited most of the shrub areas of California, studied the plants in their native habitats, transplanted more than 300 species to trial gardens at Mills College, where they were under close observation for structural variations, and examined type specimens and living material in some of the world's principal herbaria and botanic gardens.

HERBERT B. NICHOLS

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BRIEFLY REVIEWED

American Wildlife and Plants. Alexander C. Martin, Herbert S. Zim, and Arnold L. Nelson. ix + 500 pp. Illus. $7.50. McGraw-Hill, New York. 1951.

THIS book is a concentrated summary of the researches into food habits that have been carried out since 1885 by the Fish and Wildlife Service and the Biological Survey. Plant foods are considered in detail, and animal food is summarized in a general statement. By the use of symbols, small graphs, and range maps, a great deal of information, including in many cases the differing percentages of plant food by season and the total number of animal stomachs examined, is packed into a small space. Many of the animals and plants are illustrated by small vignettes. The book is arranged in three parts: a general introduction, treatment of the animals by groups and species, and a similar section for the plant species, with lists of the animals that feed upon them. This cross-referenced arrangement, together with the index, makes the book very handy to use, and it will undoubtedly be an essential handbook for wildlife specialists.

JOEL W. HEDGPETH

La Jolla, California

The Main Stream of Mathematics. Edna E. Kramer. xii + 321 pp. Illus. $5.00. Oxford University Press, New York. 1951.

THE aim of this scholarly book seems to be to review for the reader some of the subject matter of mathematics, well mingled with its history, its philosophy, and its importance. It is neither a textbook nor a popular treatise, but an attempt to make thinking people better acquainted with mathematics and mathematicians. The print is clear, the paper and binding of good quality.

An introductory chapter takes up history and number systems. It is followed by chapters on geometry, on algebra and electricity, on mysticism in mathematics, on electronics and imaginary quantities, and on astronomy and trigonometry. The work of Descartes introduces a chapter on analytical geometry. Games of chance and probability lead up to statistical analysis in an eighth chapter. Another chapter begins with achievements of women mathematicians and leads up to mathematical series. A chapter on elementary calculus starts with Newton's contributions. Non-Euclidean geometry is introduced in a chapter headed "From Alice to Einstein," the "Alice" referring to Dodgson, the author of *Alice in Wonderland*. The next chapter is upon theory of relativity as recently developed; the last upon the concept of infinity, discussing Cantor's contributions and Zeno's paradoxes. A short list of references is appended.

The book is not very well outlined or documented, and shows traces of the influence of the physical sciences. The mathematical developments are correct but not complex or difficult; they are not carried to advanced stages. In each chapter they are interwoven with the history of the subject, mathematical personalities, and interesting connections. The book discusses beginnings made by the Chaldeans, the Hindus, and the Chinese; the achievements and limitations of the ancient Greeks, of the Europeans of the sixteenth century, and others. The author seems to enjoy mentioning little-known workers who have made contributions to the subject. Many graphs are included, and some show mathematical figures and ratios appearing in art and nature. The common-sense introductions to non-Euclidean geometry, infinity, and relativity are especially valuable. The book is stimulating.

F. M. WADLEY

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Einfuhrung in die Physik. Vol. I, *Mechanics, Hydromechanics, and Thermodynamics.* P. Frauenfelder and P. Huber. 492 pp. Illus. 18.50 fr. Ernst Reinhardt Verlag, A. G., Basel. 1951.

THIS introduction to general physics is written as a text for self-study, to help the student in the natural sciences who has taken the lecture course in experimental physics to understand not only the experimental details, but also the theoretical background.

The volume treats mechanics, thermodynamics, and elasticity, using vector algebra and calculus throughout. A chapter on kinetic theory is particularly clearly written and the chapter following, on the structure of solids, should help to make clear the problems in solid state physics usually slighted in elementary physics. The book closes with an application of the first and second law of thermodynamics, in a rather condensed fashion—more like a summary than a text. The book is well printed, clearly written, and will help beginning graduate students of physics to correlate experimental and theoretical facts.

KARL LARK-HOROVITZ

Department of Physics
Purdue University

LETTERS

TO A SCIENTIST PREPARING A BIBLIOGRAPHY

If in your field you would succeed,
Achieve distinction graphic,
These simple rules do well to heed
In work bibliographic.

In references that you create
(Though read them you may never),
The longer list that you can state
The wiser your endeavor.

A Ztschr.'s never out of place
And *Forschung* adds a flavor,
For foreign items lend a grace
Which *cognoscenti* savor.

Then, each and every work you wrote
(Though clearly unrelated)
Should be, in some way, made a quote
And consequently rated.

One other canon you should use
In planning lists of reference;
Quote no one with opposing views;
Agreement's given preference.

Once all these rules you have obeyed,
Next choose the proper journal,
Then trust the efforts you've essayed
Will make your work eternal.

ARTHUR J. BACHRACH

Division of Clinical and Medical Psychology
University of Virginia

SAILORS PLEASE WRITE

I have just finished reading and enjoying, in the August 1951 issue, the article "Native Astronomy in Micronesia: A Rudimentary Science," by Ward H. Goodenough. However, his explanation of how a sailing canoe can be kept on a true course does not fit in with what I think I have learned from amateur sailing.

The first difficulty, and perhaps the only one, is that of terminology. "Loss of way" means, as I understand it, a loss of speed in the direction from stern to bow. Such a loss can be critical in changing tacks, because steering a sailing vessel is possible only when sufficient way is maintained.

The effect due to the lateral component of the wind's force is often called "sagging off to leeward." The usual means of correction is to sail "above the true course." This is, of course, where the skill of the navigator is tested. The resultant of the motion from stern to bow, or apparent course, and the motion to leeward, should be a motion along the true course.

From the description of the asymmetrical hull of the sailing canoe, it seems to me that, with the outrigger to windward and the canoe heeled over so that the outrigger is out of the water, the curve of the hull would force the canoe to fall off to leeward. By this I mean to tend to sail away from the wind. When the outrigger is in the water, I would expect it to tend to act as a pivot forcing the canoe to come up into the wind. You will note that these are the reverse of the directions given by Professor Goodenough. This may be because Professor Goodenough and I do not mean the same thing by "fall off to leeward."

Another way of looking at the effect of the outrigger would be in terms of a steering paddle. When the outrigger, or the paddle, is dipped into the water, the canoe will tend to turn toward the side on which the outrigger, or paddle, is located. This is, of course, simply a means of steering. If the navigator wishes to "fetch" a distant island in a single tack, using any method of steering, he has his choice of two methods. He can bear up into the wind periodically to compensate for the distance lost to leeward, thus sailing a zig-zag course. On the other hand, he can sail a straight course by keeping his apparent course to windward of the objective.

I am by no means an expert in matters nautical. However, I am sufficiently confused that I would appreciate your having a nautical expert explain, preferably with diagrams, how an asymmetrical sailing canoe works. Then perhaps I would no longer feel, with the Bellman, that "the bowsprit got mixed with the rudder sometimes."

JOHN J. MITCHELL

Fishkill, New York

ASSOCIATION AFFAIRS

THE SEVENTH PHILADELPHIA MEETING DECEMBER 26–31, 1951

PLANS for the 118th meeting of the American Association for the Advancement of Science in the city where it was founded, in 1848, are proceeding on schedule. As forecast in the Preliminary Announcement (*Science*, **113**, 635 [1951]), there will be outstanding programs in every principal field of science. A new section, Section P—Industrial Science, overwhelmingly approved by a vote of the Council, will be inaugurated at this meeting.

Sectional Programs. All 18 of the Association's sections and subsections have developed plans for programs, largely of the symposium type. Sections also scheduling sessions for contributed papers include:

Section C—Chemistry, Ed. F. Degering, Buckman Laboratories, Inc., 1256 North McLean Street, Memphis 8, Tennessee
Section E—Geology and Geography, Leland Horberg, University of Chicago
Section G—Botanical Sciences, Stanley A. Cain, University of Michigan
Section H—Anthropology, Marian Smith, Columbia University
Section I—Psychology, Delos Wickens, Ohio State University
Subsection Nd—Dentistry, Russell A. Bunting, University of Michigan
Subsection Np—Pharmacy, Glenn L. Jenkins, Purdue University
Section Q—Education, Dean A. Worcester, University of Nebraska

Those who wish to read papers in one of the above sections should submit titles and abstracts to the respective secretaries before *September 30*. Most of the sectional programs will be held in Philadelphia's Municipal Auditorium, or "Convention Hall."

Programs of the Participating Societies. The details of the sessions of the societies meeting with the AAAS will appear at a later date. Most of these sessions will be in the downtown hotels, but exceptions include the symposium "Radioisotopes in Medicine," sponsored by the Oak Ridge Institute of Nuclear Studies; the demonstration sessions of the American Society of Zoologists; and the evening lectures of the National Geographic Society, Phi Beta Kappa, and Phi Kappa Phi—all of which are scheduled for Convention Hall or university auditoriums near by. The Convention Hall will also house the Main Registration and Information Center, the 150-booth Annual Exposition of Science and Industry, the AAAS Science Theatre, the Visible Directory of Registrants, a Holland-operated Restaurant, and the Biologists' Smoker.

Local Institutions Participating in the Programs

Amateur Telescope Makers of The Franklin Institute
Byrn Mawr College, Department of Geology
City Planning Commission, City of Philadelphia
Drexel Institute of Technology, College of Engineering
Engineers' Club of Philadelphia
Fels Planetarium, The Franklin Institute
Pennsylvania Academy of Science
Philadelphia Botanical Club
Rittenhouse Astronomical Society
Swarthmore College, Division of Engineering
Towne Scientific School, University of Pennsylvania
University Museum, University of Pennsylvania
Villanova College, Department of Engineering

Housing and Registration

The hotels of Philadelphia have pledged themselves to provide ample housing, at moderate rates, for those attending the 118th meeting. Housing will be handled by the Philadelphia Convention and Visitors Bureau. Special forms in triplicate that prevent errors and provide for "desired rate" and "maximum rate" will be used; confirmations will be made promptly. The large number of hotels cooperating ensures a wide latitude of choice.

Full-page announcements of these hotels, their rate schedules, and a coupon for room reservations will be found in the advertising pages of SCIENCE for August 24 and in this month's issue of THE SCIENTIFIC MONTHLY. Headquarters for the sections and participating societies follow:

Hotel Headquarters

Bellevue-Stratford: (750 rooms) Broad & Walnut Sts.	AAAS; Press; AAAS Sections A, H, I, K L, and Q; AAAS Cooperative Committee; Academy Conference; Biometric Society, Eastern North American Region; Society for American Archaeology; Society for Research in Child Development; American Home Economics Association, American Sociological Society, National Academy of Economics and Political Science, Pi Gamma Mu; Eastern Division of the American Philosophical Association, Philosophy of Science Association; American Association of Scientific Workers, American Library Association, Conference on Scientific Manpower, Honor Society of Phi Kappa Phi, National Association of Science Writers, Scientific Research Society of America, Sigma Delta Epsilon, Society of the Sigma Xi, Special Libraries Association, United Chapters of Phi Beta Kappa.

Benjamin Franklin: (1200 rooms) 9th & Chestnut Sts.	AAAS Sections F, G, N (including Subsections Nm, Nd, and Np), and O; American Society of Protozoologists, American Society of Zoologists, Herpetologists League, Society of Systematic Zoology; American Microscopical Society, American Society of Limnology and Oceanography, Beta Beta Beta, Ecological Society of America, Genetics Society of America; Botanical Society of America; Alpha Epsilon Delta; American Association of Colleges of Pharmacy, American College of Apothecaries, American Pharmaceutical Association, American Society of Hospital Pharmacists.
Adelphia: (400 rooms) 13th & Chestnut Sts.	National Association of Biology Teachers; National Science Teachers Association; American Nature Study Society.
John Bartram: (400 rooms) Broad & Locust Sts.	AAAS Sections B, C, D, and E; American Meteorological Society, Oak Ridge Institute of Nuclear Studies; National Geographic Society, National Speleological Society. (Register at Bellevue-Stratford or Convention Hall.)
Sylvania: (400 rooms) Locust St., near Broad	AAAS Sections M and P; American Industrial Hygiene Association. (Register at Bellevue-Stratford or Convention Hall.)

The following additional hotels are available for sleeping rooms:

Barclay (600 rooms), Rittenhouse Sq., E.
Drake (700 rooms), 1512 Spruce St.
Essex (225 rooms), 13th & Filbert Sts.
Penn Sheraton (600 rooms), 39th & Chestnut Sts.
Ritz-Carlton (200 rooms), Broad & Walnut Sts.
Robert Morris (200 rooms), 17th & Arch Sts.
St. James (125 rooms), 13th & Walnut Sts.
Warwick (900 rooms), 17th & Locust Sts.

Guests in these hotels should register at Convention Hall or the Bellevue-Stratford.

Advance Registration

The Council of the Association favors retaining Advance Registration, which has obvious advantages—provided programs are not delayed by heavy preholiday mail. Last year's experiment of sending the 304-page General Program early in December by first-class mail was so successful that it will be done again this year. A full-page announcement on Advance Registration and an accompanying coupon will be found in the advertising pages of SCIENCE for August 24 and in this month's issue of THE SCIENTIFIC MONTHLY. Coupons for Advance Registration can be accepted through *December 6*. Facilities for registration at the meeting will open Wednesday, December 26. AAAS registration fees have not changed—they are still $2.00 for members, for husbands or wives of registrants, and for bona fide students; and $3.00 for non-members. An additional 25¢ for advance registration partly covers first-class mailing costs.

The Local Committee

It would be impossible to make successful arrangements for the large and complex meetings of the Association, to ensure the smooth operation of each session, to secure adequate local public information, and to finance the meetings without the very considerable personal services of members of the local committee, and they merit the unstinted appreciation of all who attend. Among those who have agreed to serve are the following:

Honorary General Chairman: Edward Hopkinson, Jr., Drexel & Co.

General Chairman: James Creese, president, Drexel Institute of Technology.

Executive Committee: James Creese, president, Drexel Institute of Technology, *chairman; Allen T. Bonnell,* vice president, Drexel Institute of Technology, *secretary; Henry B. Allen,* executive vice president and secretary, The Franklin Institute; *Walter H. Annenberg,* publisher, Philadelphia *Inquirer; George B. Beitzel,* president, Pennsylvania Salt Manufacturing Company; *Henry Bryans,* president, Philadelphia Electric Company; *Richard H. DeMott,* president, SKF Industries, Inc.; *Hugh W. Field,* vice president and general manager, Atlantic Refining Company; *John M. Fogg, Jr.*, vice provost, University of Pennsylvania; *Wilfred D. Gillen,* president, Bell Telephone Company of Pennsylvania; *Albert M. Greenfield,* president, Albert M. Greenfield & Company; *Edward Hopkinson, Jr.,* Drexel & Co.; *C. Mahlon Kline,* president, Smith, Kline & French Laboratories; *Harry A. Kuljian,* president, The Kuljian Corporation; *M. Albert Linton,* president, Provident Mutual Life Insurance Co.; *Thomas McCabe,* president, Scott Paper Company; *Richard T. Nalle,* president, The Midvale Company; *Charles S. Redding,* president, Leeds & Northrup Company; *R. W. Slocum,* general manager, Philadelphia *Evening Bulletin;* and *Steven M. Spencer,* associate editor, Curtis Publishing Company.

A General Reception Committee of 124 members, representing science, industry, education, and professional science writing, has been appointed, as have subcommittees on Exhibits, Local Public Information, and Physical Arrangements.

RAYMOND L. TAYLOR
Assistant Administrative Secretary